GreetGeo

Funded by the European Union

GREEN TRANSITION WITH GEOTHERMAL ENERGY

Geothermal concept-level business cases

Twenty opportunities for energy, industry and regional cooperation

A collection of concept-level business cases across **6 value chains** was developed through the Greet GEO deep and shallow geothermal pilot action reports (D3.5 and D3.6). Explore how geothermal resources can support electricity, heating and cooling, industrial processes and new products.

6
value chains

20
business cases

From resource development to practical investment opportunities

Explore the concept-level business cases

Each concept is presented across two pages: the idea and how it works, followed by its business opportunity, validation needs and replication potential. These are **development concepts**; anticipated benefits and proposed targets are not confirmed project results.

DEEP GEOTHERMAL

GEOTHERMAL POWER AND UPSTREAM

- A1 Energy, water and food hubs
- A2 Flash steam electricity
- A3 Modular power generation

THERMAL USES AND DISTRICT HEATING AND COOLING

- B4 District heating development
- B5 Hybrid renewable district heating
- B6 Heat recovery for spas

GEOTHERMAL BRINE VALORISATION

- C7 Lithium recovery
- C8 Cosmetic materials
- C9 Methanol production
- C10 CO2 recovery and use

AGRIFOOD AND INDUSTRIAL GEOTHERMAL APPLICATIONS

- D11 Paper production heat
- D12 Microalgae cultivation
- D13 Brewing
- D14 District heating with agriculture
- D15 Dairy processing

SHALLOW GEOTHERMAL

URBAN GEOTHERMAL DISTRICT ENERGY INFRASTRUCTURE

- S1 Historic districts
- S2 Seasonal storage
- S3 Reusing wells

INDUSTRIAL GROUND SOURCE HEAT PUMPS

- S4 Heat pump manufacturing
- S5 Heat pumps in industry

DEEP GEOTHERMAL BUSINESS CASES

A1 Geothermal energy water and food hubs 4

A2 Flash steam geothermal electricity 6

A3 Modular geothermal power generation 8

B4 Geothermal district heating development 10

B5 Hybrid renewable district heating 12

B6 Geothermal heat recovery for spas 14

C7 Geothermal energy and lithium recovery 16

Explore the concept-level business cases

DEEP GEOTHERMAL BUSINESS CASES (CONTINUED)

C8 Geothermal materials for cosmetics 18

C9 Geothermal energy for methanol production 20

C10 Recovery and use of geothermal carbon dioxide 22

D11 Geothermal process heat for paper production 24

D12 Geothermal heat for microalgae cultivation 26

D13 Geothermal heat for brewing 28

D14 District heating linked to agriculture 30

D15 Geothermal heat for dairy processing 32

SHALLOW GEOTHERMAL BUSINESS CASES

S1 Geothermal energy in historic districts 34

S2 Geothermal heating and cooling with seasonal storage 36

S3 Reusing wells for urban geothermal energy 38

S4 Heat pump manufacturing and supply chains 40

S5 Scaling geothermal heat pumps in industry 42

READING THE CONCEPTS

Replication depends on local resource conditions, demand, engineering, permissions and financing. The performance measures listed in each entry identify what should be assessed when developing an investment.

DEEP GEOTHERMAL | POWER & UPSTREAM

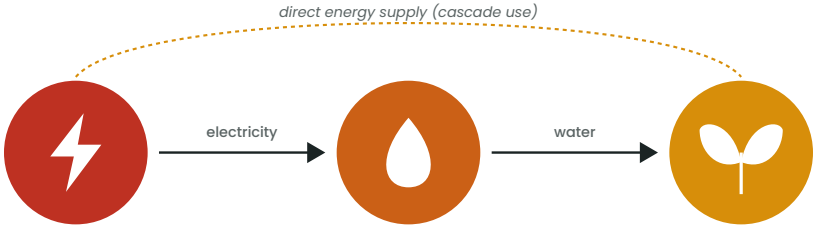
Zero-Emission Geothermal Energy-Water-Food Hub

for island energy security and climate resilience

THE IDEA

A **deep geothermal closed-loop power plant** delivers reliable renewable baseload electricity with **no routine atmospheric emissions** and **no geothermal fluid discharge**. Applying a cascade-use approach, this energy also powers desalination plants, farms and agro-food industries, creating an integrated **Energy-Water-Food ecosystem** that strengthens resource resilience for an island economy.

ONE ENERGY SOURCE, THREE VALUE CHAINS



Closed-loop geothermal power
Baseload renewable electricity, zero routine emissions

Desalination
Secure, sustainable and lower-carbon water production

Agriculture & agro-food
Irrigation and processing with resilient, affordable supply

WHY IT IS NEEDED

~97%
of primary energy demand relies on imported fossil fuels, exposing the island to price and supply shocks

Water
scarcity is growing, making energy-hungry desalination an essential part of the water system

0
commercial-scale deep geothermal plants so far: high perceived risk and few reference projects

Why closed-loop? It provides dispatchable power that complements variable solar and wind, while protecting the environment. Early, transparent engagement with island communities builds the social licence to operate.

From exploration to bankable investment

FOUR-PHASE ROADMAP

1 PHASE 1 of 4

Resource validation

- Analyse exploration and drilling data
- Resource modelling
- Technical, economic and environmental feasibility

Output: Feasibility study

2 PHASE 2 of 4

Business model

- Identify electricity off-takers
- Map water and agri-food demand
- Financial modelling, SME engagement

Output: Integrated business model

3 PHASE 3 of 4

Demonstration

- Validate geothermal desalination
- Living-lab and stakeholder activities
- Pilot value-chain concepts

Output: Validated business concept

4 PHASE 4 of 4

Investment and replication

- Bankable investment documents
- Financing and risk-sharing strategies
- Replication framework

Output: Investment-ready roadmap

WHAT THE BUSINESS CASE WILL DELIVER

- **1** bankable investment project for a closed-loop power plant
- **1** integrated geothermal-powered desalination concept
- **1** pilot Energy-Water-Food value chain
- **20+** stakeholders engaged in validating the business model
- **5+** capacity-building and engagement activities
- **10+** SME business opportunities identified
- **1** investment roadmap and risk-mitigation framework
- **1** replication roadmap for other island and outermost regions
- **1** community-engagement programme to build social licence

EXPECTED IMPACTS

Energy

- Energy independence from local resources
- Less dependence on imported fossil fuels
- Dispatchable power for grid stability

Environment

- Zero direct operational emissions
- Fossil-based generation displaced
- Better water resilience

Economy

- New geothermal value chains
- Skilled jobs and SME growth
- Investment-ready infrastructure

Society

- Public trust through living labs
- Stronger energy and water security
- Territorial cohesion

BUILT TO LAST BEYOND PROJECT FUNDING

Electricity sales | Power supply for desalination | Energy services for agri-food | Technology licensing and replication | Training and innovation services

DEEP GEOTHERMAL | POWER GENERATION

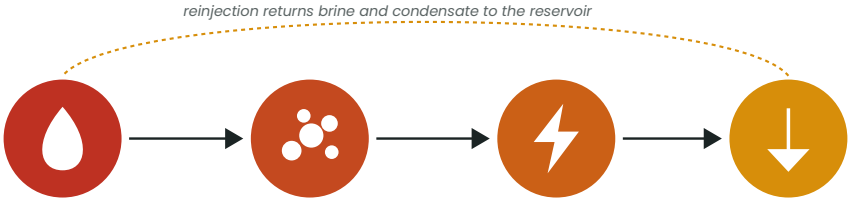
Flash Steam Geothermal Power Plants

firm, carbon-free electricity from high-temperature resources

THE IDEA

A commercial-scale **flash steam power plant** taps high-temperature geothermal reservoirs and turns naturally pressurised hot water into steam that drives a turbine. The result is **24/7 renewable baseload power** with capacity factors above 85%, independent of weather and season. Next-generation designs aim for higher efficiency, lower costs and smaller environmental impact, giving Europe a **dispatchable partner for wind and solar**.

HOW A FLASH PLANT WORKS



1 Production well
Pressurised water at 150-370 °C rises to the surface

2 Flash vessel
Pressure drops, part of the water flashes into steam

3 Turbine
Steam spins the turbine and generator

4 Reinjection
Brine returns underground, sustaining the reservoir

WHY IT IS NEEDED

>85%
capacity factor: stable, high-load electricity that supports grid stability

24/7
carbon-free power from an indigenous source, independent of weather or season

Risk
high upfront costs and exploration and drilling risk still hold back deployment

Why flash? It is the most common geothermal power technology and uses the resource's own steam directly, with no intermediate heat exchange, giving high output from high-temperature fields.

From optimised design to market replication

FOUR-PHASE ROADMAP (42-48 MONTHS)

1 PHASE 1 of 4

R&D and design

- Resource assessment, reservoir modelling
- Multi-flash and turbine optimisation
- Binary-cycle and heat integration options

Output: Optimised plant design

2 PHASE 2 of 4

Prototyping

- Pilot wells, separators, turbines
- Control and monitoring systems
- Integration tuned to reservoir conditions

Output: Pilot-scale system

3 PHASE 3 of 4

Demonstration

- Operate the plant in real conditions
- Track efficiency, reliability, emissions
- Validate KPIs in a living lab

Output: Validated performance data

4 PHASE 4 of 4

Market uptake

- Techno-economic assessment
- Bankable business models
- Replication packages, investor engagement

Output: Replication packages

TARGETS

≥10-20%
increase in plant conversion efficiency

≥15-25%
reduction in levelised cost of electricity

≥20%
higher resource utilisation (energy per well)

1
optimised flash plant at pilot or commercial scale

Cleaner
improved fluid management and emissions control

Ready
standard designs, models and investment templates

KEY RISKS AND HOW THEY ARE MANAGED

Geological
3D seismic, numerical modelling, advanced exploration and real-time monitoring

Financial
Early investor engagement and de-risking strategies for upfront costs

Technical
Modular system design and staged implementation of integrated systems

EXPECTED IMPACTS

Energy

- Firm, dispatchable renewable power
- Less reliance on imported fossil fuels
- Stronger regional energy security

Environment

- Near-zero operational emissions
- Reinjection sustains the reservoir
- Minimal land use

Economy

- Growth of local supply chains
- Stable long-term power revenue
- Co-generation and grid services

Society

- Skilled jobs and upskilling
- Stronger public acceptance
- Stable energy costs for communities

DEEP GEOTHERMAL | POWER & UPSTREAM

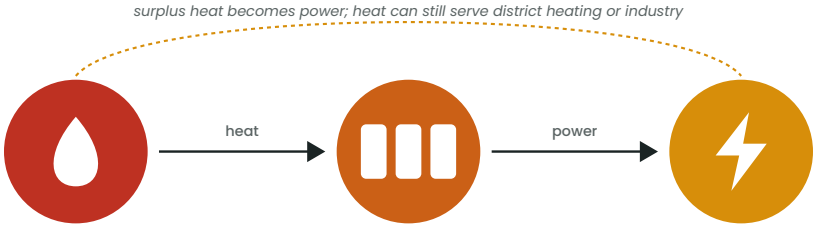
Modular ORC Power Generation Solutions

plug-and-play power from low- and medium-temperature heat

THE IDEA

Standardised **Organic Rankine Cycle (ORC) modules** convert low- to medium-temperature geothermal heat into electricity, unlocking resources that would otherwise stay **underused or stranded**. Units can sit at the wellhead right after well testing, then be expanded, relocated or combined with district heating as the project matures. The result is **earlier revenue, lower risk and a replicable model** for sedimentary basins.

FROM HOT WATER TO POWER AND HEAT



Geothermal well
Hot water from 80 °C, typically 100-180 °C

Modular ORC units
Containerised modules, added or moved as needed

Power and heat
Electricity from surplus heat, plus direct heat use

WHY MODULAR ORC

80 °C
lowest source temperature that can still generate power; typically 100-180 °C

TRL 8-9
near-market, standardised technology that cuts engineering effort and capital risk

Day 1
power can start right after well testing, shortening the time to revenue

Why modular? Conventional plants are large and tailored to one reservoir. Modules scale with reservoir performance and heat demand, with full reinjection and minimal environmental impact.

From proven technology to scalable deployment

FOUR-PHASE ROADMAP (TRL 7-9: INTEGRATION AND VALIDATION)

1 PHASE 1 of 4

Adaptation and design

- Assess temperature, flow, chemistry
- Site-specific system configuration
- Grid, permitting, digital monitoring

Output: Site-specific design

2 PHASE 2 of 4

Commissioning

- Install ORC units on existing infrastructure
- Mechanical and electrical integration
- Initial testing, performance baselines

Output: Commissioned system

3 PHASE 3 of 4

Demonstration

- Continuous operation, varying heat demand
- Hybrid use with heating or industry
- Advanced controls, impact monitoring

Output: Performance evidence

4 PHASE 4 of 4

Market uptake

- Standardised replication models
- Bankable cases for follow-up sites
- Engage financiers and authorities

Output: Replication models

TARGETS

70-80%
of unused or surplus geothermal heat converted into electricity

80-180 °C
resource range enabled for power generation

Early
revenue within the first operational phase of a well

Scalable
units adapted to reservoir size and development stage

Lower
emissions by displacing fossil-based electricity

Stronger
value chain linking upstream to downstream

KEY RISKS AND HOW THEY ARE MANAGED

Geological
Existing wells, phased deployment and early performance validation

Integration
Standardised interfaces and modular system architecture

Financial and market
Early revenue, phased investment, early permitting talks and real-condition demonstration

EXPECTED IMPACTS

Energy

- More dispatchable renewable power
- Higher yield from existing wells
- Less reliance on imported fossil fuels

Environment

- Fossil-based electricity displaced
- Full reinjection protects the reservoir
- Less thermal waste

Economy

- Earlier revenue from wells
- Demand for local services and SMEs
- Investment-ready replication models

Society

- Greater public trust
- Energy security and price stability
- Balanced growth of towns and rural areas

DEEP & SHALLOW GEOTHERMAL | HEAT

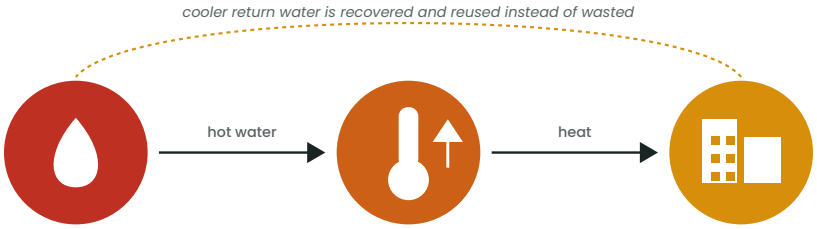
Geothermal District Heating Development

stable, local, decarbonised heat for our cities

THE IDEA

Many cities already have geothermal district heating, but it can work far harder. Two demonstration networks combine **heat pumps** that recover heat from return water with **digital heat regulation and billing** in apartment buildings. Together with **bankable business models** and a **replication pipeline**, this turns proven technology into investment-ready projects across European regions.

SMARTER USE OF EVERY DEGREE



Geothermal wells
Local renewable baseload heat for the city

Heat pumps and network
Recover low-grade heat, cut network losses

Apartment buildings
Digital regulation and billing reduce peak demand

WHY IT IS NEEDED

77 M
Europeans use district heating, yet geothermal supplies under 3% of it

25%+
of the EU population lives in areas directly suitable for geothermal district heating

360+
geothermal heating and cooling projects are in development, enough to double capacity in 4-5 years

Why now? Peak heat is still largely met by natural gas. Cutting peak load and waste heat lowers fuel imports, shields households from price shocks and keeps heat networks viable.

From demonstration sites to an investment pipeline

THREE-PHASE ROADMAP

1 PHASE 1 of 3

Technical integration

- Heat pumps on low-grade return water
- Digital heat regulation and billing in buildings
- Cut gas-based peak load by at least a quarter

Output: Upgraded networks

2 PHASE 2 of 3

Optimisation and business models

- Monitor and tune with digital tools
- Collect data for validation
- Bankable business models: costs, revenues, financing, risks

Output: Validated, bankable models

3 PHASE 3 of 3

Replication pipeline

- Standard technical configurations
- Guidelines for different regulatory and market contexts
- Support third-party projects, mobilise capital

Output: Replication framework

TARGETS

≥25%
cut in peak load now met by natural gas

>85%
renewable heat share in the demonstration networks

2
demonstration sites in less developed regions

1
replication framework and investment pipeline

€60,000
support for third parties preparing projects elsewhere

Bankable
business models and financing schemes

KEY RISKS AND HOW THEY ARE MANAGED

Political and regulatory
Convincing policy-makers of the benefits of geothermal heat

Implementation
Clear communication, one-stop shops, standard solution models, peer learning

Financial
Financially viable projects, financial structuring and risk mitigation

EXPECTED IMPACTS

Energy	Environment	Economy	Society
• Stable, local baseload heat	• Lower fossil fuel use and emissions	• Real references for SMEs and suppliers	• Lower risk of energy poverty
• Less gas needed for peak demand	• Less waste heat in networks	• Follow-up investment mobilised	• Affordable, reliable city heat
• Higher renewable heat share	• Fuller use of the resource	• Viable heat-supply revenues	• Stronger interregional cooperation

DEEP GEOTHERMAL | THERMAL USES AND DHC

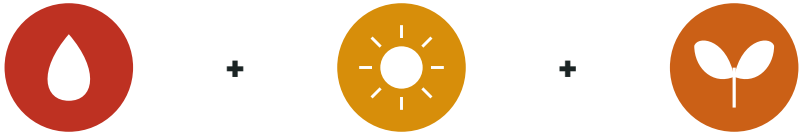
Hybrid Geothermal-Solar-Biomass District Heating

resilient, low-carbon city heat from three complementary sources

THE IDEA

A gas-dependent district heating network becomes a **hybrid renewable system**. Deep geothermal wells supply year-round **baseload heat**, solar thermal adds low-cost summer heat and biomass gives flexible peak capacity, with gas boilers kept only as backup. **Digital optimisation**, **bankable business models** and a **replication pipeline** turn one demonstrator into a model for other cities.

THREE SOURCES, ONE NETWORK



Geothermal
Stable baseload heat, all year

Solar thermal
Low-cost heat, strongest in summer

Biomass
Flexible peak and backup capacity

ONE DIGITALLY OPTIMISED NETWORK | GAS KEPT AS BACKUP ONLY

WHY HYBRID

<3%
geothermal share of European district heating energy, despite its stable baseload potential

<0.5%
solar thermal share: cheap, but seasonal and of limited use without storage

1/3+
of district heating energy is biomass, a scarce resource that is not always sustainable

Why combine them? Each source covers another's weakness. Together, with heat storage and digital control, they give a reliable, flexible and decarbonised supply.

From a city demonstrator to a replicable model

FIVE-PHASE ROADMAP

1 PHASE	2 PHASE	3 PHASE	4 PHASE	5 PHASE
Integration	**Optimisation**	**Business models**	**Replication**	**Pipeline**
• Drilling and wells • Link geothermal, solar, biomass	• Digital monitoring • Demand-side management	• Costs, revenues, financing • Risk mitigation	• Standard configurations • Implementation guidelines	• Investment-ready portfolio • Follow-up capital mobilised
Output: Hybrid system	**Output:** Validated data	**Output:** Bankable models	**Output:** Replication framework	**Output:** Investment pipeline

TARGETS

10 MWth
maximum geothermal baseload heat from the new wells

≥15 GWh
less gas used every year (minimum)

>95%
system availability demonstrated

>85%
renewable share of the network's heat

>10,000 t
of CO2 emissions avoided every year

1
replication framework and investment pipeline

KEY RISKS AND HOW THEY ARE MANAGED

Geological
Geophysical study, 3D seismic survey and numerical modelling of the resource

Financial
Phased investment, combining local, national and EU funding

Social acceptance
Early communication with the local community and transparent activities

EXPECTED IMPACTS

Energy	Environment	Economy	Society
• Stable baseload heat all year • Less exposure to gas prices • Gas kept only as backup	• Over 10,000 t CO2 avoided a year • Over 85% renewable heat • Fossil gas replaced	• Real references for SMEs • Follow-up investment mobilised • Heat revenues sustain operation	• Secure, affordable heat • Early, transparent community dialogue • Model for medium-sized cities

THERMAL USES | SPAS AND WELLNESS

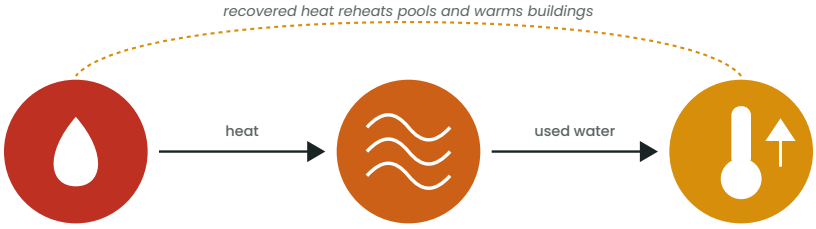
Geothermal Balneology and Wellness

lower heating costs and less fossil fuel for thermal spas

THE IDEA

Thermal spas need **low-temperature heat all year round**, exactly what thermal aquifers provide. **Heat pumps** recover the residual heat of used thermal water to reheat pools, heat buildings and supply hot water, backed by **digital regulation** and rooftop solar. A real-life demonstration, **bankable business models** and a **replication pipeline** carry the approach to spas across Europe.

HEAT THAT IS USED TWICE



Thermal water
Low-temperature heat, available year-round

Pools and wellness
Constant demand for bathing, heating and hot water

Heat pump
Recovers heat from water flowing away

A LARGE, HEAT-HUNGRY SECTOR

5,000+
thermal and mineral spring establishments in Europe

150–200 M
annual spa visits in Europe, a large share at thermal and geothermal spas

€18 bn+
yearly revenue generated by thermal and mineral springs in Europe

Why heat pumps? They move 3-4 times more heat than the electricity they use, replacing fossil boilers and cutting operating costs at a time when spa demand is under pressure.

From one spa demonstrator to a sector-wide pipeline

THREE-PHASE ROADMAP

1 PHASE 1 of 3

Technical integration

- Heat pumps on residual thermal water
- Digital heat regulation
- Buffer tank and rooftop solar

Output: Upgraded heating system

2 PHASE 2 of 3

Optimisation and business models

- Monitor and optimise digitally
- Operational data for validation
- Bankable business models and financing

Output: Validated, bankable models

3 PHASE 3 of 3

Replication pipeline

- Standard technical configurations
- Guidelines for different regulatory contexts
- Support third-party projects, mobilise capital

Output: Replication framework

TARGETS

350 kWth
planned heat pump capacity covering the whole spa building

250 m³
thermal water buffer tank that captures heat when pools are refilled

60 kWp
rooftop solar keeping extra electricity use low

€60,000
support for third parties preparing projects elsewhere

1
replication framework and investment pipeline

Bankable
business models and financing schemes

KEY RISKS AND HOW THEY ARE MANAGED

Water safety
Frequent complete water testing and automatic temperature control

Resource
Sustainable reservoir management, reinjection and continuous monitoring

Technical
Corrosion-resistant materials and scale inhibitors where needed

EXPECTED IMPACTS

Energy
- Lower heating costs
- Less fossil fuel for heat
- Solar offsets extra electricity

Environment
- Lower greenhouse gas emissions
- Less thermal pollution of waters
- Better resource efficiency

Economy
- Lower operating costs for spas
- Real references for SMEs
- Follow-up investment mobilised

Society
- Spa services stay affordable
- Supports health and wellness tourism
- Stronger interregional cooperation

BRINE VALORISATION | CRITICAL RAW MATERIALS

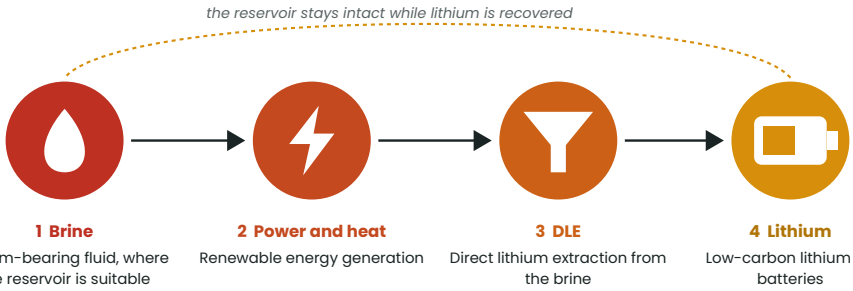
Geothermal Lithium Extraction

towards tri-generation revenues: power, heat and lithium

THE IDEA

Some geothermal brines, in specific rock settings, carry lithium, but recovery is commercially viable only at high enough concentrations and flow rates, so every reservoir must be assessed. Where it works, **Direct Lithium Extraction (DLE)** recovers lithium while the same resource produces **renewable power and heat**, giving a project three revenue streams instead of one. The aim is **low-carbon, domestic lithium** for Europe's battery industry.

ONE RESOURCE, THREE PRODUCTS



WHY IT IS NEEDED

Imports
Europe relies heavily on external suppliers for lithium, a key battery material

3 in 1
electricity, heat and lithium from one suitable geothermal resource

Cleaner
than conventional mining: less land use, less water, lower emissions

Why geothermal lithium? Where the brine is suitable, it is already produced for energy. Recovering lithium from it supports the energy transition and a resilient European battery value chain.

From resource to industrial-scale lithium

FOUR-PHASE ROADMAP (48 MONTHS)

PHASE 1 of 4 — Feasibility

- Resource characterisation
- Lithium concentration analysis
- Reservoir modelling, techno-economics

Output: Feasibility study

PHASE 2 of 4 — Technology

- Optimise DLE technologies
- Laboratory validation
- Renewable energy integration

Output: Optimised DLE process

PHASE 3 of 4 — Pilot

- Pilot-scale demonstration
- Geothermal energy and lithium co-production

Output: Pilot results

PHASE 4 of 4 — Market uptake

- Commercial development planning
- Investment readiness, regulatory alignment
- Stakeholder engagement

Output: Market-ready plan

TARGETS

48 months
from resource characterisation to market uptake

1
co-production demonstration at industrial scale

Lower
greenhouse gas emissions than imported lithium

Lower
land use than conventional mining

Closed-loop
systems reduce water consumption

Renewable
fully renewable operational energy

KEY RISKS AND HOW THEY ARE MANAGED

Technical
Lithium concentration variability and DLE scaling, tracked by continuous monitoring

Resource
Reservoir sustainability safeguarded by monitoring and diversified deployment sites

Societal
Stakeholder engagement to address public acceptance

EXPECTED IMPACTS

Energy

- Fully renewable operational energy
- Geothermal heat and power
- Cleaner industrial supply

Environment

- Lower emissions than imports
- Less land use than mining
- Lower water consumption

Economy

- More domestic raw materials
- Competitive battery value chain
- Skilled jobs, regional growth

Society

- Strategic autonomy and resilience
- Higher environmental and social standards
- Open stakeholder dialogue

BY-PRODUCT VALORISATION | COSMETICS

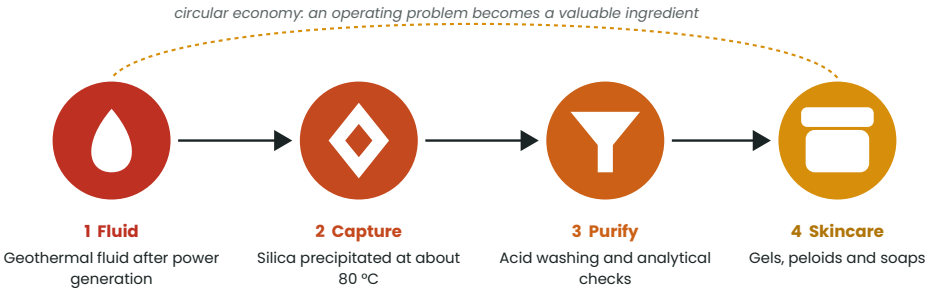
Geothermal By-Products in Dermocosmetics

from a costly scaling problem to a premium skincare ingredient

THE IDEA

After power generation, geothermal fluid deposits **amorphous silica** that clogs pipes and reinjection wells. Captured and purified, it becomes a high-value ingredient. Together with **volcanic pumice** and **thermal mud**, it forms a premium natural dermocosmetic line that replaces **microplastics and synthetic polymers**.

FROM SCALING TO SKINCARE



KEY NUMBERS

90%+
of dissolved silica removed within the first 5-10 minutes of treatment

125 µm
pumice grain size, limited to 1% of a formula for a gentle exfoliation

2.5 t
of microplastics and synthetic polymers removed from EU cosmetics every year

Why now? EU rules restrict microplastics and synthetic exfoliants in cosmetics, opening a gap for natural, traceable mineral ingredients from geothermal plants.

From laboratory bench to international market

FOUR-PHASE ROADMAP (36 MONTHS)

PHASE 1 of 4

R&D

- Pilot silica extraction and purification
- Pumice sieved to 125 microns
- Stability tests of natural gelling network

Output: Purified ingredients

PHASE 2 of 4

Scale-up

- Technology transfer to industry
- GMP pilot batches
- Sterilisation validated at scale

Output: GMP pilot batches

PHASE 3 of 4

Clinical trials

- Patch tests, 100 volunteers
- Skin safety and efficacy
- Sensory tests in luxury spas

Output: Clinical evidence

PHASE 4 of 4

Launch

- Product information files
- EU cosmetics notification
- Distribution channels activated

Output: Market launch

TARGETS

5
product references: soap, two peloids, exfoliating gel, silica gel mask

100
volunteers in clinical patch tests

1%
maximum pumice content, at 125 micron grain size

3 cycles
of thermal sterilisation, no chemical preservatives

2.5 t
microplastics and polymers removed yearly

Natural
gelling network replaces synthetic polymers

KEY RISKS AND HOW THEY ARE MANAGED

Raw material
Batch-by-batch XRD/XRF checks; acid washing and ICP-MS before shipment

Formulation
Natural gelling network stable in salty media; pumice capped at 1%

Market
Texture testing and odour masking with neutral essential oils

EXPECTED IMPACTS

Energy

- Less scaling in plants
- Lower maintenance and downtime
- Better plant economics

Environment

- Fewer microplastics in cosmetics
- Mineral waste eliminated
- Waterless products cut transport

Economy

- New high-value market from by-products
- Skilled jobs near the resource
- Export-ready premium line

Society

- Safe, clinically validated skincare
- Less isolation of remote regions
- Model for other volcanic regions

CO2 UTILISATION | POWER-TO-X

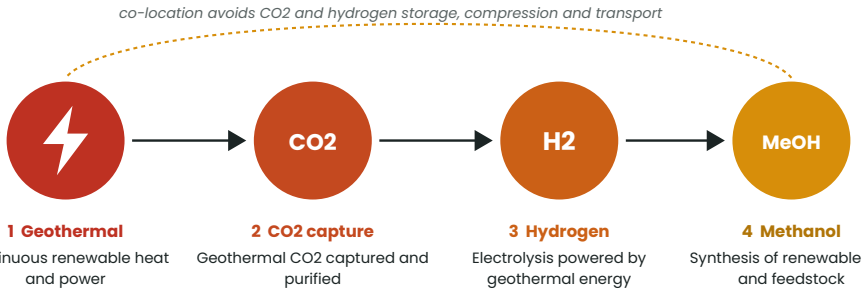
Geothermal Methanol and CO2 Production

baseload geothermal energy turns CO2 into renewable fuel

THE IDEA

Geothermal sites offer **24/7 heat and power** and often a steady stream of **CO2**. Together they run hydrogen electrolysis and methanol synthesis in one place, producing **renewable methanol** for shipping, chemicals and industry. A waste stream becomes a feedstock, with **far lower lifecycle emissions** than fossil-based methanol.

FROM GEOTHERMAL SITE TO GREEN FUEL



WHY IT IS NEEDED

24/7
baseload heat and power keeps electrolysis and synthesis running without intermittency

70–90%
lower lifecycle CO2 emissions targeted compared with conventional methanol

Fossil
methanol from natural gas still dominates, with a large carbon footprint

Why geothermal? Wind- and solar-based e-fuels depend on intermittent power. Geothermal gives steady energy and a pure CO2 source on the same site, cutting energy losses.

From integrated design to circular carbon hubs

FOUR-PHASE ROADMAP (42-48 MONTHS)

1 PHASE 1 of 4

R&D and design

- Integrate geothermal, electrolysis, CO2 capture
- Process modelling, energy flows
- Select technologies

Output: System design

2 PHASE 2 of 4

Prototyping

- Pilot-scale components
- Electrolysers, capture units, reactors
- SME control systems

Output: Pilot system

3 PHASE 3 of 4

Demonstration

- Run under real industrial conditions
- Track efficiency, CO2 use, yield
- Living lab

Output: Performance data

4 PHASE 4 of 4

Market uptake

- Techno-economic and lifecycle analysis
- Replication packages
- Investor and policy engagement

Output: Replication packages

TARGETS

≥70-90%
lower lifecycle CO2 emissions than conventional methanol

1
integrated pilot or pre-commercial geothermal methanol system

CO2 in
captured CO2 streams used as feedstock

Methanol
renewable output at competitive energy efficiency

Replicable
techno-economics validated across contexts

24/7
renewable heat and power for continuous operation

KEY RISKS AND HOW THEY ARE MANAGED

Technical
Modular design and advanced controls balance geothermal supply and electrolysis demand

Financial
Early financial modelling and investor engagement strengthen bankability

Regulatory
Early alignment with EU frameworks on CO2 use and fuel certification

EXPECTED IMPACTS

Energy

- Baseload renewable heat and power
- Geothermal used beyond power
- Less reliance on fossil imports

Environment

- Large cut in lifecycle emissions
- CO2 becomes a resource
- Closed-loop carbon system

Economy

- New regional industrial hubs
- Green technology jobs
- Competitive local fuel supply

Society

- Skills and capacity building
- Wider acceptance of CCU and e-fuels
- Local energy autonomy

BRINE VALORISATION | CIRCULAR CARBON

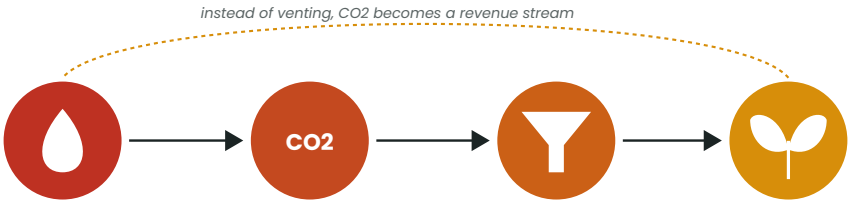
Geothermal CO2 Utilisation

turning a vented by-product into a marketable resource

THE IDEA

Geothermal brines carry **dissolved CO2**, which is usually vented or only partly used. Captured, purified and compressed on site, it can supply **greenhouses, food and beverage producers, industry and synthetic fuels**. The result is **new revenue** for geothermal projects, lower emissions and a regional circular carbon economy.

FROM BRINE TO END USER



1 Brine
Dissolved CO2 reaches the surface in normal production

2 Separation
Gas separated from the brine

3 Purify
Purified, compressed and stored

4 End users
Greenhouses, drinks, industry, e-fuels

WHY IT IS NEEDED

20–40%
higher greenhouse crop yields with CO2 enrichment at 800–1000 ppm

Vented
CO2 from geothermal fluids is often released or only partly used

Rising
demand for non-fossil CO2 as traditional fossil-based supply declines

Why geothermal? Wells already bring dissolved gas to the surface, so capture needs no extra energy input, unlike conventional carbon capture, and CO2 supply is continuous and local.

From brine analysis to industrial symbiosis

FOUR-PHASE ROADMAP

1 PHASE 1 of 4

Characterisation

- Brine composition, dissolved gases
- Production profiles
- Suitability for end uses

Output: CO2 resource profile

2 PHASE 2 of 4

System design

- Gas separation and purification
- Compression, storage, monitoring
- Integration with operations

Output: Integrated design

3 PHASE 3 of 4

Demonstration

- Operate under real conditions
- Greenhouse, industry or e-fuel users
- Industrial validation

Output: Validated performance

4 PHASE 4 of 4

Scale-up

- Standard replication models
- Investment packages
- Interregional frameworks

Output: Replication models

TARGETS

1
replicable, investment-ready CO2 utilisation model

New
revenue streams from CO2 sales

Lower
direct emissions: CO2 used, not vented

Local
low-carbon CO2 supply for nearby farms and industry

Off-take
long-term agreements with CO2 users

Modular
systems replicable across sedimentary regions

KEY RISKS AND HOW THEY ARE MANAGED

Technical
Fluid characterisation, adaptable separation, modular design and monitoring

Market and finance
Long-term off-take agreements, phased investment and bankable pilots

Regulatory and social
Early dialogue with authorities, transparent communication, monitoring

EXPECTED IMPACTS

Energy

- Better geothermal project economics
- Heat and CO2 from one site
- More local resource autonomy

Environment

- Lower greenhouse gas emissions
- CO2 used, not vented
- Circular carbon use

Economy

- New circular value chains
- Investment chances for SMEs
- Less need for subsidies

Society

- Diversified economies in geothermal regions
- Stronger interregional cooperation
- Territorial cohesion

INDUSTRIAL HEAT | PAPER AND PULP

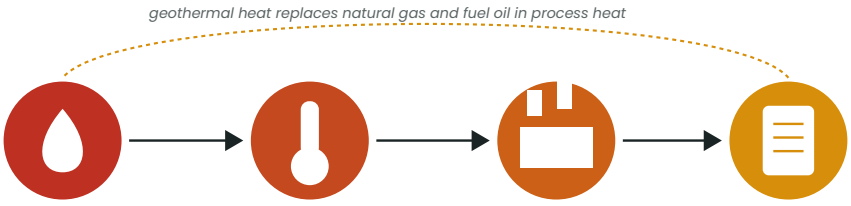
Geothermal Heat for the Paper Industry

renewable baseload process heat for heat-hungry factories

THE IDEA

Paper and pulp mills need **continuous medium- and high-temperature heat** for pulp treatment, drying and steam, mostly from natural gas and fuel oil. Geothermal heat plugged directly into the **industrial process systems** replaces fossil fuels with **renewable baseload heat**, cutting emissions and stabilising energy costs while keeping production reliable.

FROM THE GROUND TO THE PAPER MACHINE



1 Geothermal heat
Renewable baseload, available continuously

2 Heat system
Delivered into industrial process systems

3 Mill
Pulp treatment, drying, steam generation

4 Products
Low-carbon paper and pulp

WHY IT IS NEEDED

24/7
uninterrupted production needs an uninterrupted, predictable heat supply

Gas
natural gas and fuel oil still provide much of the industry's process heat

Hard
industrial heat is among the hardest areas to decarbonise; electrification alone is not enough

Why geothermal? Unlike intermittent renewables, it delivers continuous, predictable heat with low lifecycle emissions, shielding mills from volatile fossil fuel prices.

From heat demand to decarbonised production

FIVE-PHASE ROADMAP (48 MONTHS)

1 PHASE	2 PHASE	3 PHASE	4 PHASE	5 PHASE
Feasibility	**Design**	**Pilot**	**Validation**	**Scaling**
• Industrial heat demand • Geothermal resource • Techno-economics	• Geothermal engineering • Industrial integration • Sustainability check	• Drilling, heat production • Process integration • Environmental monitoring	• Performance validation • Lifecycle assessment • Replication planning	• Dissemination • Stakeholder engagement • Commercial planning
Output: Feasibility study	**Output:** Engineering design	**Output:** Pilot plant	**Output:** Validated results	**Output:** Scaling plan

TARGETS

Less
natural gas consumption in process heat

Lower
CO2 emissions through renewable heat substitution

Stable
energy costs, less price volatility

Baseload
continuous renewable process heat

1
scalable model for other mills and regions

48 months
from feasibility to market uptake

KEY GAPS AND THE IMPACT EXPECTED

Fossil dependence
Mills rely on gas-based steam. Impact: less fossil use and long-term energy stability

No renewable baseload
Most renewables are intermittent. Impact: stable industrial heat generation

Fragmented ecosystem
Developers and manufacturers rarely cooperate. Impact: faster industrial deployment

EXPECTED IMPACTS

Energy	Environment	Economy	Society
• Renewable baseload process heat • Less dependence on fossil fuels • Higher energy resilience	• Lower greenhouse gas emissions • Path to climate-neutral industry • Low lifecycle emissions	• Predictable energy costs • Stronger industrial competitiveness • Faster industrial deployment	• Regional economic development • Stronger energy security • Cooperation across sectors

WASTE HEAT | BIOECONOMY

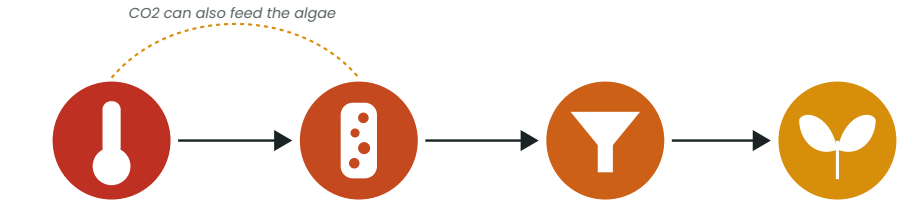
Geothermal Microalgae Cultivation

residual geothermal heat grows high-value algae all year round

THE IDEA

Geothermal plants release **40–90 °C residual heat** after producing electricity. It keeps microalgae **photobioreactors and ponds** at the ideal temperature and powers drying and extraction, while geothermal CO2 can feed the algae. The biomass becomes **supplements, pigments, omega-3, cosmetics, feed and biofuels**: new revenue for both sectors.

FROM WASTE HEAT TO BIOPRODUCTS



1 Waste heat
Residual 40–90 °C heat after power generation

2 Cultivation
Photobioreactors and ponds at stable temperature

3 Processing
Harvest, low-temperature drying, extraction

4 Bioproducts
Food, feed, pigments, cosmetics, biofuels

TARGETS AT A GLANCE

30–50%
at least this cut in external energy demand for cultivation, through geothermal integration

≥20%
higher biomass productivity thanks to stable, weather-independent temperatures

≥40%
lower lifecycle greenhouse gas emissions than conventional algae production

Why geothermal? Constant, weather-independent heat suits temperature-sensitive cultures, extends the growing season in cool climates and cuts the energy cost of drying and extraction.

From pilot modules to bioeconomy hubs

FOUR-PHASE ROADMAP

PHASE 1 of 4 — R&D and design

- Site and resource assessment
- Direct or heat-pump integration
- Algae strain selection

Output: Integrated design

PHASE 2 of 4 — Prototyping

- Pilot heat-exchange modules
- Cultivation units, photobioreactors
- Performance monitoring

Output: Pilot modules

PHASE 3 of 4 — Demonstration

- Pre-commercial, continuous operation
- Energy, productivity, cost data
- Living lab

Output: Performance data

PHASE 4 of 4 — Market deployment

- Business model validation
- Replication packages
- Investors and guidelines

Output: Replication packages

TARGETS

30–50%
minimum cut in external energy demand for cultivation

≥20%
higher biomass productivity than baseline

≥40%
lower lifecycle emissions than conventional algae production

1
integrated pilot at pre-commercial scale

3
climatic and geological contexts for replication models

1 ha
reference plant scale studied for commercial production

KEY RISKS AND HOW THEY ARE MANAGED

Technical
Advanced modelling, modular design and iterative testing under real conditions

Financial
Phased investment, combined local, national and EU funding, robust business models

Environmental and regulatory
Early consultation with authorities; compliance built into the design

EXPECTED IMPACTS

Energy

- Better geothermal plant efficiency
- Fossil heating replaced
- Lower operating energy costs

Environment

- Lower greenhouse gas emissions
- Heat and CO2 reused
- Circular resource use

Economy

- New revenue for geothermal operators
- Diversified algae product markets
- New bioeconomy clusters

Society

- Green jobs, knowledge transfer
- Local value chains
- Acceptance of renewables

INDUSTRIAL HEAT | FOOD AND BEVERAGE

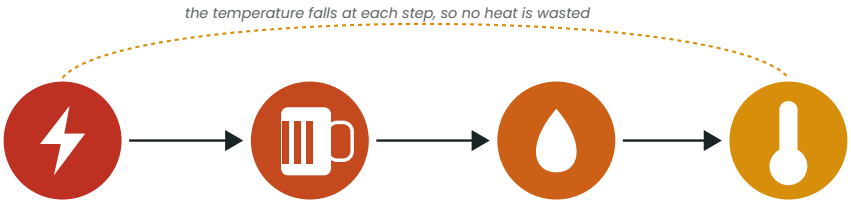
Geothermal Heat for Brewing

cascading residual geothermal heat through the brewery

THE IDEA

Breweries need **continuous medium-temperature heat** for mashing, wort boiling, conditioning and cleaning, mostly from fossil fuels. Residual heat from geothermal plants, normally reinjected unused, is **cascaded through the brewery**: hotter steps via heat pumps or hybrid systems, cooler steps directly. One geothermal source replaces fossil heat across the whole process.

HEAT USED STEP BY STEP



1 Electricity
The geothermal plant generates power first

2 Brewing
Mashing and wort boiling, with heat pumps or hybrid

3 Cleaning
Cleaning-in-place and conditioning

4 Pre-heating
Pre-heating and space heating

TARGETS AT A GLANCE

40–60%
less fossil fuel consumption in the participating brewery processes

≥40%
lower CO_2 emissions than conventional heat supply

≥25%
higher overall thermal efficiency through cascade heat reuse

Why geothermal? Breweries need steady heat at several temperature levels. Geothermal is continuous and low-carbon, and cascade use matches each process to the right temperature.

From pilot brewery to replication packages

FOUR-PHASE ROADMAP (36-48 MONTHS)

PHASE 1 1 of 4

R&D and design

- Brewery energy demand profiles
- Cascade design: direct use or heat pump
- Baseline assessments

Output: Cascade design

PHASE 2 2 of 4

Prototyping

- Pilot cascade in a partner brewery
- Heat exchangers, storage, controls
- Dynamic heat allocation

Output: Pilot system

PHASE 3 3 of 4

Demonstration

- Operate in real conditions
- Efficiency, fossil savings, emissions
- Validate KPIs

Output: Validated KPIs

PHASE 4 4 of 4

Market uptake

- Techno-economic analysis
- Investment cases
- Replication packages

Output: Replication packages

TARGETS

40-60%
less fossil fuel in participating brewery processes

≥40%
lower CO_2 emissions than conventional heat

≥25%
higher thermal efficiency through cascade reuse

1
operational cascade system at pilot or pre-commercial scale

3
brewery types or regional contexts for replication models

SMEs
replicable model tailored to small breweries

KEY RISKS AND HOW THEY ARE MANAGED

Technical
Modular, flexible design with monitoring and control to match supply and process temperatures

Financial
Phased investment, combined local, national and EU funding, early investor engagement

Regulatory
Alignment with EU frameworks and early engagement with authorities

EXPECTED IMPACTS

Energy

- Fossil fuel use cut by 40-60%
- Higher thermal efficiency
- Long-term heat supply agreements

Environment

- Lower CO_2 emissions
- Better air quality
- Efficient cascade use of energy

Economy

- Lower brewery energy costs
- New market for geothermal heat
- Extends to dairies, distilleries

Society

- Jobs and skills development
- Local energy autonomy
- Acceptance of renewables

DISTRICT HEATING | AGRICULTURE

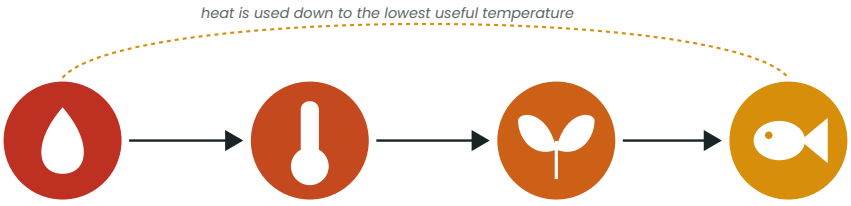
Geothermal District Heating for Agriculture

cascading geothermal heat from the network to greenhouses and fish farms

THE IDEA

Geothermal district heating networks often release warm water that still holds useful heat. This case **cascades that heat to agriculture**: first the network, then greenhouses, then fish farms, with heat pumps recovering what is left. A working demonstrator (TRL 6 or higher) is used to build a **replication framework and an investment pipeline** for other regions.

HEAT USED STEP BY STEP



1 Deep geothermal
Wells supply hot water to the plant

2 District heating
Heat for homes and buildings

3 Greenhouses
Crops placed by temperature need

4 Fish farming
Remaining warm water, after heat pump recovery

TARGETS AT A GLANCE

20 MWth
of renewable heat generated at the demonstrator

≥25%
less natural gas use, as the pilot target

40,000 t
CO2 avoided per year through lower fossil fuel use

Why geothermal? Europe imports gas for heat and vegetables. Cascade use cuts both: cheaper, local, low-carbon heat for farmers and a steadier local food supply.

From one demonstrator to a replication pipeline

FOUR-PHASE ROADMAP (48 MONTHS)

1	2	3	4
MONTHS 1-12	MONTHS 13-30	MONTHS 31-42	MONTHS 43-48

Feasibility

- Geological studies
- Heat demand mapping
- Farm user identification

Output: Feasibility base

Development and demo

- Wells and network
- Heat exchange systems
- Agricultural pilot, digital monitoring

Output: Working pilot

Optimisation

- Operational testing
- Agricultural and environmental assessment
- Business models

Output: Validated data

Replication

- Standard technical set-ups
- Implementation guidelines
- Investment pipeline

Output: Replication framework

TARGETS

20 MWth
renewable heat generated

5+
agricultural facilities connected

40,000 t
CO2 reduction per year

20+
SMEs involved

3
new business models developed

6
regions engaged

KEY RISKS AND HOW THEY ARE MANAGED

Geological
Advanced exploration, insurance and national risk schemes where available

Financial
Blended finance with possible EU support; phased scaling of proven pilots

Market and policy
Long-term supply contracts; early engagement of policy makers

EXPECTED IMPACTS

Environment

- Significant CO2 reduction
- More renewable heat
- Better energy efficiency

Social

- Rural jobs and skills
- Regional resilience
- Affordable energy

Territory

- Stronger innovation ecosystems
- More competitive SMEs
- Higher farm productivity

Beneficiaries

- Municipalities: decarbonised heat
- Farmers: lower costs
- Citizens: stable prices

INDUSTRIAL HEAT | DAIRY SECTOR

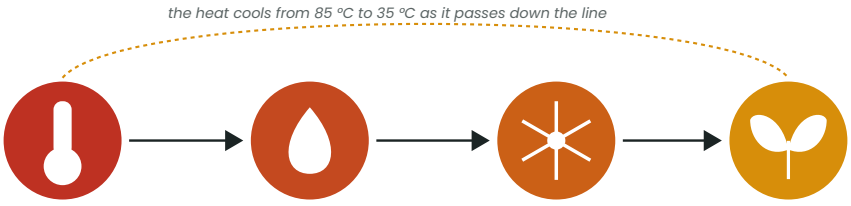
Geothermal Cascade for Dairy Processing

a shared heat network that reuses residual heat from geothermal power plants

THE IDEA

Geothermal power plants release brine at about 100 °C that still holds a lot of heat. This case **recovers that heat in a dedicated network** and passes it through dairies, cleaning, cooling and agriculture. A closed double loop keeps the geothermal fluid **fully separate** from food processing. It adapts a model already proven in dairies elsewhere in Europe.

HEAT USED STEP BY STEP



1 Pasteurisation
Milk and cheese processes, 85 to 72 °C

2 Cleaning
Clean-in-place and hot water, 72 to 60 °C

3 Cooling
Absorption chillers for cheese curing, 60 to 45 °C

4 Drying and growing
Fodder drying and greenhouses, 45 to 35 °C

TARGETS AT A GLANCE

3,200 t
CO2-equivalent avoided per year

2,100 t
of fossil fuel equivalent displaced each year

40 °C
final brine temperature, from about 100 °C, before full reinjection

Why geothermal? Dairies need steady heat all year, and geothermal supplies it. Cascade use replaces imported fossil fuel with local heat at a stable, predictable cost.

From waste heat to a shared utility

FOUR-PHASE ROADMAP (32 MONTHS)

1 MONTHS 1-10

Engineering and licensing

- Geochemical modelling
- Environmental impact assessment
- Pipeline route optimisation

Output: Permits and design

2 MONTHS 11-16

Base infrastructure

- Titanium heat exchanger station
- Insulated twin-pipe network

Output: Primary circuit

3 MONTHS 17-22

User substations

- Automated substations at users
- Heat meters and control valves

Output: Cascade connected

4 MONTHS 23-32

Commercial operation

- Heat supply contracts
- Indicators and impact reporting

Output: Validated model

TARGETS

3,200 t
CO2-equivalent avoided per year

2,100 t
fossil fuel equivalent displaced per year

2.5 km
pre-insulated twin-pipe network

4
temperature levels in the cascade

15 years
heat supply contracts, take-or-pay

1,200+
dairy-producing families indirectly supported

KEY RISKS AND HOW THEY ARE MANAGED

Geochemical
Titanium and steel equipment, spare exchangers and cleaning against scaling

Geological
Flexible pipes across fault zones, with expansion joints and fibre-optic monitoring

Commercial
15-year take-or-pay contracts with anchor users, protecting debt service

EXPECTED IMPACTS

Dairies

- Lower, stable heat costs
- Less fossil fuel exposure
- Lower-carbon products

Energy operator

- New revenue from a by-product
- Better use of the resource
- Reservoir kept intact

Agriculture

- Low-cost heat for greenhouses
- Crop and fodder drying
- More resilient farms

Territory

- Skilled technical jobs
- Energy autonomy
- Base for new users

SHALLOW GEOTHERMAL | HISTORIC CITIES

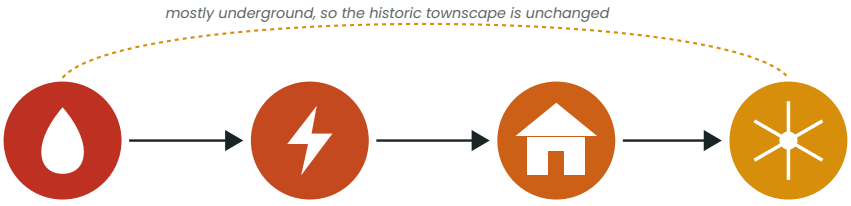
Heritage-Compatible Geothermal Heating and Cooling

district energy that stays out of sight in protected city centres

THE IDEA

Historic centres must cut emissions and cope with hotter summers, yet heritage rules limit façade insulation, rooftop renewables and scattered air-conditioning units. This case uses **shallow geothermal heat** in a **low-temperature district network** for heating and cooling, largely invisible from the surface. A real demonstrator creates the evidence investors need to **replicate it across Europe**.

FROM GROUND TO BUILDING



1 Groundwater
Shallow resource, available all year

2 Heat pumps
Supply heat in winter and cooling in summer

3 Network
Low-temperature pipes serve many buildings

4 Heating and cooling
Public buildings, businesses and homes

TARGETS AT A GLANCE

1 system
for heating and cooling instead of fossil boilers and separate air-conditioning units

Hidden
underground infrastructure that preserves the look of protected buildings

Bankable
investment-ready model backed by real operating data

Why geothermal? Heritage rules restrict most retrofit options, while heatwaves raise cooling demand. Geothermal gives reliable, local, low-carbon heating and cooling without touching façades or roofs.

From one demonstrator to many historic centres

FIVE-PHASE ROADMAP

PHASE 1 of 5 — Assessment and design

- Hydrogeological studies
- Heating and cooling demand analysis

Output: Investment-ready concept

PHASE 2 of 5 — Engineering and permits

- Detailed engineering designs
- Early talks with heritage bodies

Output: Permits and value chain

PHASE 3 of 5 — Construction

- Wells, heat pumps, network
- Minimal disruption to the centre

Output: Working system

PHASE 4 of 5 — Validation

- Monitor performance across seasons
- Digital optimisation

Output: Evidence for investors

PHASE 5 of 5 — Replication

- Design templates and guidelines
- Investment pipeline

Output: Replication framework

TARGETS

1 real-life demonstrator in a protected historic centre

4 regions identified for replication

5 phases from design to market uptake

8 risk areas identified and managed

SMEs drilling, network and digital firms join a cross-border value chain

Revenue from heating and cooling services sustains operation after EU funding

KEY RISKS AND HOW THEY ARE MANAGED

Subsurface
Detailed hydrogeological studies, thermal modelling and phased drilling

Financial
Bankable models built on validated data and phased investment

Permits
Early talks with authorities, heritage bodies and local stakeholders

EXPECTED IMPACTS

Heritage
- Cooling without visible units
- Visual character preserved
- Protected buildings intact

Climate
- Fossil heating replaced
- Lower emissions
- Better efficiency

Economy
- Stable energy costs
- SMEs reach new markets
- Demand for local services

Investors
- Lower investment risk
- Validated performance data
- Ready-to-use replication tools

SHALLOW GEOTHERMAL | CAMPUSES

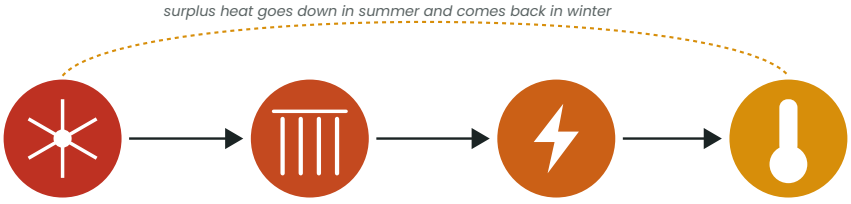
Geothermal Heating and Cooling with Seasonal Storage

heat pumps and underground thermal storage for campus district energy

THE IDEA

Campuses need heat in winter and cooling in summer, mostly from gas boilers and separate cooling units. This case couples **ground-source heat pumps** with **borehole thermal energy storage**: surplus summer heat is stored underground and reused in winter, through a low-temperature network serving several buildings. A full-scale demonstrator builds the case for **universities, hospitals and business parks**.

THE GROUND AS A SEASONAL BATTERY



1 Summer cooling
Cooling the buildings leaves surplus heat

2 Ground store
Boreholes hold the heat until winter

3 Heat pumps
Lift the stored heat to useful levels

4 Winter heating
Low-temperature network to campus buildings

TARGETS AT A GLANCE

60–70%
less fossil fuel for space heating and cooling in participating buildings

≥65%
lower CO2 emissions than gas heating and standard cooling

>4.0
seasonal performance factor from combined heat pump and storage operation

Why geothermal? Campuses have concentrated, predictable demand and single ownership, so they make ideal anchor users. Storing heat underground evens out the seasons and cuts electricity peaks.

From one demonstrator to many campuses

FIVE-PHASE ROADMAP

1 PHASE 1 of 5	2 PHASE 2 of 5	3 PHASE 3 of 5	4 PHASE 4 of 5	5 PHASE 5 of 5
Assessment and design • Hydrogeological characterisation • Campus demand analysis	**Engineering and permits** • Detailed design and permitting • Drilling, HVAC and digital SMEs join	**Construction** • Boreholes and heat pumps • Connection of several buildings	**Validation** • Seasonal storage and efficiency data • Digital optimisation	**Replication** • Design templates and guidelines • Investment pipeline
Output: Site-specific design	**Output:** Permits and value chain	**Output:** Working system	**Output:** Evidence for investors	**Output:** Replication framework

TARGETS

60–70%
less fossil fuel for space heating and cooling

≥65%
lower CO2 emissions than conventional gas-based supply

>4.0
seasonal performance factor to be demonstrated

Seasonal
heat and cold recovery validated over annual cycles

SMEs
drilling, HVAC and digital firms join a cross-border value chain

1
documented, investment-ready reference model

KEY RISKS AND HOW THEY ARE MANAGED

Subsurface
Hydrogeological studies, thermal modelling and phased drilling

Integration
Stepwise integration, SME involvement and monitoring during commissioning

Financial
Bankable models built on validated data and phased investment

EXPECTED IMPACTS

Climate	Grid	Users	Economy
• Fossil fuel use cut by 60–70% • CO2 down by at least 65% • More renewable heat and cold	• Lower peak electricity demand • Better local grid stability • Seasonal load balancing	• Stable energy costs • Better indoor comfort • Less fuel price exposure	• SMEs reach new markets • Investment pipeline • Flagship for geothermal

URBAN GEOTHERMAL | WELL REUSE

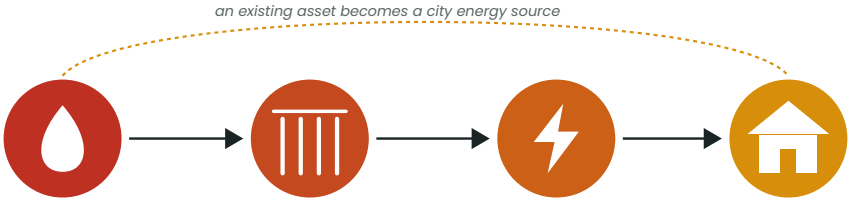
Reusing Abandoned Wells for Urban Heating and Cooling

turning an existing deep well into the heart of a city district network

THE IDEA

Many cities have deep wells built decades ago for thermal tourism or local heating that now sit underused. This case turns one such well in a historic centre into a **renewable heat source**. Its heat is boosted by **central heat pumps** and distributed through a **low-temperature network** for heating and cooling, with little impact on protected buildings.

FROM OLD WELL TO CITY NETWORK



1 Existing well
Thermal water, already explored and operated

2 Heat extraction
Heat exchange station or closed-loop design

3 Heat pumps
Boost the heat to network temperature

4 City network
Heating and cooling for the centre

TARGETS AT A GLANCE

48 °C
thermal water temperature of the existing well

Lower risk
resource already proven, so less geological uncertainty than new drilling

Replicable
model for cities with underused wells across Europe

Why geothermal? A proven resource lowers geological risk, shortens preparation and improves bankability. It also brings sustainable cooling to a protected centre without visible units.

From one old well to many cities

FIVE-PHASE ROADMAP

1 PHASE 1 of 5

Asset assessment

- Well performance and resource check
- City-centre demand analysis

Output: Technical concept

2 PHASE 2 of 5

Design and permits

- Detailed engineering and permits
- Financial planning

Output: Investment-ready project

3 PHASE 3 of 5

Deployment

- Well modernisation, heat pump plant
- Network and building connections

Output: Working system

4 PHASE 4 of 5

Validation

- Performance in real conditions
- Optimisation across seasons

Output: Evidence for investors

5 PHASE 5 of 5

Replication

- Guidelines and business models
- Future investments

Output: Replication framework

TARGETS

48 °C
thermal water temperature of the existing well

1
existing deep well reused as the primary energy source

5
phases from asset assessment to replication

8
risk areas identified and managed

5
regions with comparable wells targeted for replication

Heritage
visual impact on protected buildings kept to a minimum

KEY RISKS AND HOW THEY ARE MANAGED

Subsurface
Thermal response testing, modelling and phased validation of the closed-loop concept

Technical
Detailed design, experienced partners and performance tests at commissioning

Financial
Bankable model, phased investment and early engagement of financial partners

EXPECTED IMPACTS

Climate
- Fossil heating replaced
- Lower greenhouse gas emissions
- More renewable energy

Security
- Local, indigenous resource
- Less imported fuel
- Stable long-term costs

Comfort
- Sustainable cooling
- Better thermal comfort
- Heritage preserved

Replication
- Cities with unused wells
- Guidelines and models
- Investment pipeline

GROUND-SOURCE HEAT PUMPS | INDUSTRY

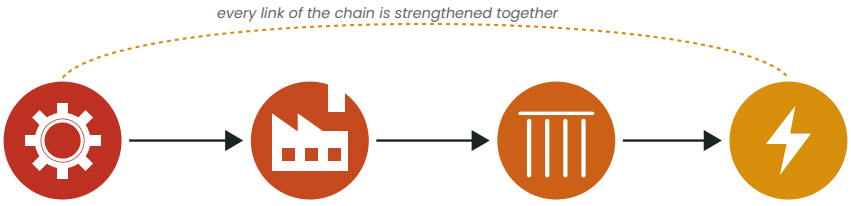
Heat Pump Manufacturing and Supply Chain

scaling up European production, sourcing and skills for ground-source heat pumps

THE IDEA

Ground-source heat pumps are mature, but supply chains are fragmented, key components are imported, systems are costly and skilled installers are scarce. This case builds an **integrated European value chain**: **manufacturing scale-up**, standard products, local sourcing, digital services and training, proven in demonstrations and packaged as a **replicable investment framework**.

FROM COMPONENT TO CUSTOMER



1 Components
Compressors, controls and heat exchangers

2 Manufacturing
Automation and standard products at scale

3 Installation
Ground loops by trained designers and drillers

4 Digital service
Remote monitoring and predictive maintenance

TARGETS AT A GLANCE

Local
sourcing of critical components to cut import dependency

Scale-up
automation and standardisation to cut costs and raise output

Skills
training and certification for installers, drillers and technicians

Why now? Heating and cooling use about half of EU final energy. Heat pumps are a strategic net-zero technology, and local manufacturing cuts import dependency.

From factory capacity to a European ecosystem

FIVE-PHASE ROADMAP

1 PHASE 1 of 5

Value chain assessment

- Capacity and supply dependencies
- Market and workforce analysis

Output: Priority investments

2 PHASE 2 of 5

Manufacturing

- Automation, standard components
- Local suppliers

Output: Scalable production

3 PHASE 3 of 5

Innovation and demo

- Digital and smart monitoring
- Residential to industrial pilots

Output: Demo evidence

4 PHASE 4 of 5

Validation and skills

- Monitoring in real conditions
- Training and certification

Output: Skilled workforce

5 PHASE 5 of 5

Replication

- Manufacturing guidelines
- Investment pipeline

Output: Replication tools

TARGETS

Local
sourcing of critical components such as compressors and controls

Scale-up
manufacturing with automation and component standardisation

Digital
IoT monitoring, remote diagnostics and predictive maintenance

Skills
training for designers, installers, drillers and technicians

4
demonstration settings: residential, commercial, industrial, district

3
regions with existing or emerging manufacturing base

KEY RISKS AND HOW THEY ARE MANAGED

Supply chain
Supplier diversification, local sourcing and strategic procurement planning

Scale-up
Gradual expansion, process optimisation, automation and quality control

Market uptake
Demonstrations, awareness raising and better business models

EXPECTED IMPACTS

Industry
- More production capacity
- Lower production costs
- Resilient supply chains

Skills
- Green jobs
- Certified installers
- Trained engineers

SMEs
- Stronger market position
- Cross-border growth
- New supplier roles

Investors
- Lower investment risk
- Technical and commercial evidence
- Investment pipeline

GROUND-SOURCE HEAT PUMPS | INDUSTRY

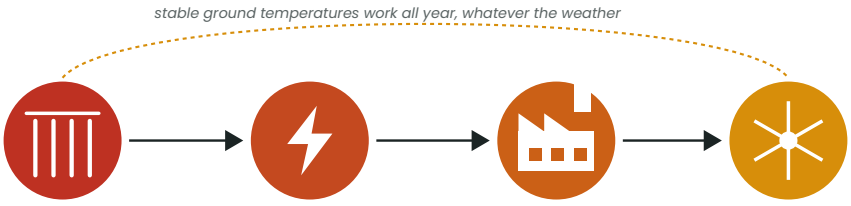
Ground-Source Heat Pumps for Industry

replacing gas heating in factories and adding cooling

THE IDEA

Industrial heat still depends largely on natural gas. This case turns a working **ground-source heat pump installation** at an energy-intensive factory into a **replication model**: boreholes and heat pumps replace gas heating and also provide cooling. Evidence from the demonstrator helps other factories and industrial parks decide to invest.

ONE SYSTEM, HEATING AND COOLING



1 Borehole field
Uses the stable temperature of the ground

2 Heat pumps
Industrial units replace gas boilers

3 Heating
Reliable heat for the factory

4 Cooling
Cooling from the same system

TARGETS AT A GLANCE

45%
CO2 emission cut achieved at the demonstration factory

200+ t
of CO2 saved per year at the demonstration factory

2 in 1
heating and cooling from a single geothermal system

Why geothermal? Gas dependence exposes industry to price shocks. A mature solution cuts fuel use and emissions, keeps production running and adds cooling.

From one factory to many industrial sites

FIVE-PHASE ROADMAP

1 PHASE 1 of 5

Site assessment

- Screen demand and gas dependency
- Preliminary geology check

Output: Promising sites

2 PHASE 2 of 5

Feasibility and design

- Borehole field and heat demand
- Technology comparison

Output: Viable projects

3 PHASE 3 of 5

Demonstration

- Factory case as evidence
- Technical and financial data

Output: Reference case

4 PHASE 4 of 5

Validation

- Monitor energy, costs, emissions
- Optimise operation

Output: Benchmarks

5 PHASE 5 of 5

Replication

- Methods and guidelines
- Investment pipeline

Output: Replication framework

TARGETS

45%
CO2 emission cut at the demonstration factory

200+ t
CO2 saved per year at the demonstration factory

2 in 1
heating and cooling from one geothermal system

5
phases from site screening to replication

8
risk areas identified and managed

Parks
factories, industrial parks and energy-intensive sectors targeted

KEY RISKS AND HOW THEY ARE MANAGED

Geological
Detailed surveys, borehole testing and experienced geothermal experts

Demand and grid
Conservative sizing and early check of grid connection needs

Cost
Contingency reserves and competitive procurement

EXPECTED IMPACTS

Industry

- Less gas dependence
- Lower, steadier running costs
- Better working conditions

Climate

- Gas heating replaced
- 45% CO2 cut demonstrated
- Long-lived assets

Value chain

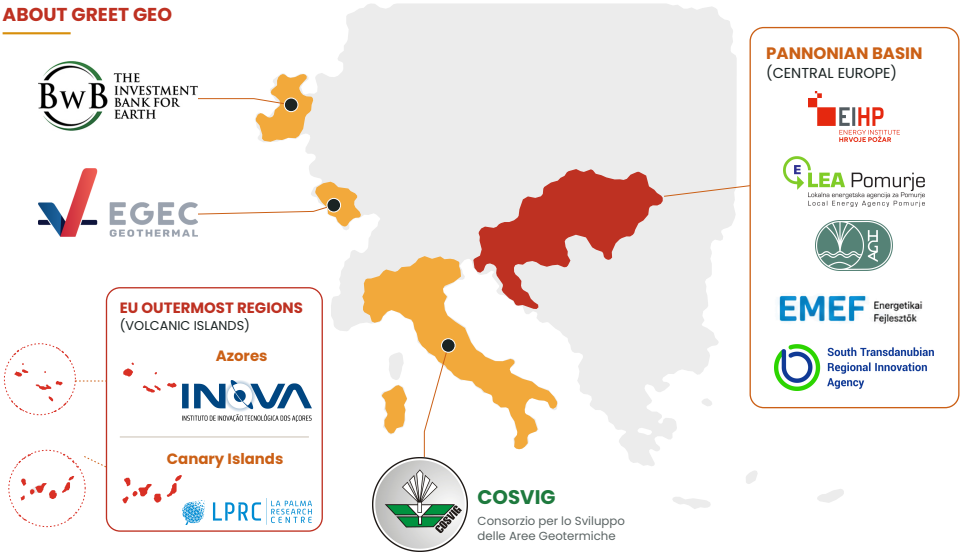
- Engineering and drilling work
- Heat pump suppliers
- New market segments

Investors

- Lower investment risk
- Bankable business models
- Investment pipeline

GreetGeo

ABOUT GREET GEO



OBJECTIVE

To foster investment in less-developed European regions through innovation and interregional cooperation that connect local stakeholders, science and industry.

PROGRAMME

European Union's Interregional Innovation Investments (I3) Instrument

DURATION

11/2024 – 10/2026

FUNDING

€1,493,532.22

FOCUS

The utilisation of geothermal resources with a holistic approach, in line with the specific domains and niches, and the needs of the target regions.

LEAD PARTNER

Energy Institute Hrvoje Požar (EIHP), Croatia

Funded by the European Union

The Greet GEO project (101180405) is supported by the European Union Interregional Innovation Investments (I3) instrument.