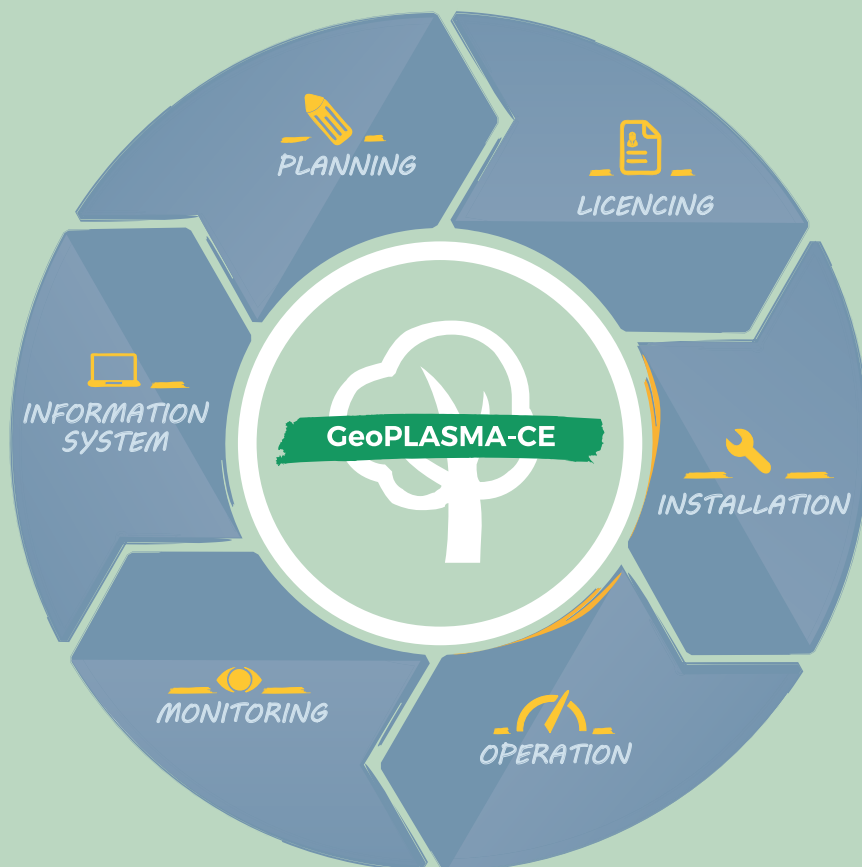


HANDBOOK

**for a successful implementation
of Shallow Geothermal Energy**



FOSTERING SHALLOW GEOTHERMAL ENERGY

Shallow geothermal energy offers a sustainable and climate-friendly supply of heating and cooling.

Although the technology is not new, it has yet to be integrated into the legal framework and energy management concepts of many regions.

This document is aimed at decision makers, authorities and experts located in those regions. It offers a very succinct compilation of aspects to consider for successful regulation and management of this energy source. The scope is limited to two common methods for the exploitation of shallow geothermal energy, closed-loop systems (borehole heat exchangers) and open-loop systems (thermal groundwater use). Ground collectors, energy piles and other methods are not covered.

Short chapters on each of the life cycle phases of a shallow geothermal energy installation emphasize their interconnections and illustrate the importance of integrated management concepts. Each chapter is accompanied by a table which summarizes the main aspects and serves as a self-assessment guide.

The document includes guidelines which provide an overview of the most important technical considerations for closed-loop systems and open-loop systems, respectively.

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Self-assessment

Each chapter includes a self-assessment section with questions about an efficient, sustainable and renewable use of Shallow Geothermal Energy (SGE) based on recommendations by GeoPLASMA-CE.

The “GeoPLASMA-CE-Self-assessment” can be applied to any regulation level (local, regional or national) and helps to evaluate the current status of SGE in your selected area. In addition, the questions also act as pointers to achieve a sustainable and efficient use and management of SGES.

INTRODUCTION



Shallow geothermal energy (SGE)

Heat from the Earth's subsurface is available everywhere. It can provide sustainable heating and cooling without emissions of gases, aerosols or noise. Utilization of this renewable energy source does not require any infrastructure apart from electricity. Shallow geothermal energy installations do not depend on fossil energy sources; this keeps operating costs stable and predictable.

This document discusses the key aspects which foster a successful introduction of shallow geothermal energy installations to emerging markets. The scope is limited to the two main applications: Closed-loop systems (borehole heat exchangers) and open-loop systems (geothermal groundwater use). Other techniques such as energy piles or ground collectors are not covered.

Closed-loop systems (CLS)

CLS use vertical pipes reaching depths that commonly range from 80 m to 150 m. The heat carrier fluid circulating in the pipes transports thermal energy through a heat exchanger to the building's heating system. CLS do not depend on groundwater availability.

Open-loop systems (OLS)

OLS extract groundwater and direct it through a heat exchanger. Afterwards, the thermally used groundwater is re-injected into the aquifer or allowed to soak away. OLS depend on groundwater presence of sufficient yield and suitable properties.

GeoPLASMA-CE Handbook

The installation and operation of any shallow geothermal energy system is subject to the applicable (national) legal framework. For this reason, aspects which are firmly anchored in the legal system are presented at the beginning of this document. They are followed by the introduction of an integrated management concept which covers all lifecycle stages of an installation. The individual stages are discussed in the following chapters. Each chapter is accompanied by a table which summarizes the main aspects and serves as a self-assessment guide.

INTRODUCTION



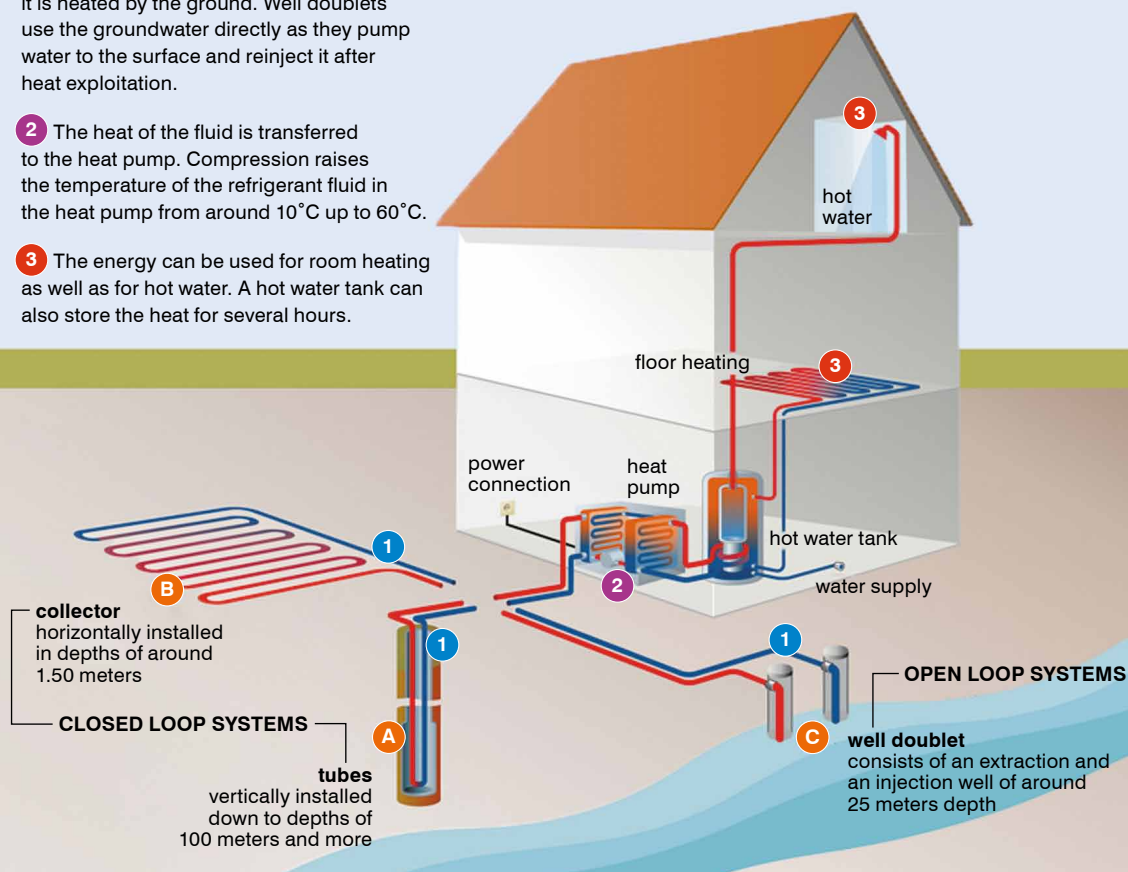
Geothermal Energy can be used by closed-loop systems using vertical tubes **A** or horizontal collectors **B**. Another possibility is the installation of a well doublet **C** as an open-loop system.

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GeoPLASMA-CE

1 While water flows in tubes or collectors, it is heated by the ground. Well doublets use the groundwater directly as they pump water to the surface and reinject it after heat exploitation.

2 The heat of the fluid is transferred to the heat pump. Compression raises the temperature of the refrigerant fluid in the heat pump from around 10°C up to 60°C.

3 The energy can be used for room heating as well as for hot water. A hot water tank can also store the heat for several hours.



5

The document concludes with an overview of the most important technical considerations for closed-loop systems and open-loop systems, respectively. More detailed information gathered by GeoPLASMA-CE is available at:

<https://portal.geoplasma-ce.eu>



PREREQUISITES

Legal Framework

The legal framework has to provide legal certainty for all actors and lays the groundwork for the licensing procedure. A binding definition of the term “shallow geothermal energy” is required. Ownership and access have to be regulated.

The documents containing the applicable technical standards have to be specified. This ensures that documents detailing the state of the art are legally binding but can easily be updated to reflect advancements in technology and knowledge.

Quality Standards

Quality standards have to ensure an installation's safety, sustainability and efficiency during its entire life cycle. Therefore, state-of-the-art procedures and specifications have to cover all aspects, including planning, choice of materials, and approved techniques or methods.

Mandatory quality control measures such as reporting and monitoring of installations have to be defined and compliance should be enforced.

More detailed technical quality standards are presented in the second part of this document – “**Guide for quality standards**”.

Certification

In order to provide knowledgeable and trained personnel for the installation and commissioning of a shallow geothermal energy system, a mandatory certification scheme for drillers, installers, planners, maintenance contractors and auditing authorities is recommended. Compliance should be verified and enforced.

A pan-European certification scheme provides harmonization and allows the entry of foreign companies into the market.

SELF ASSESSMENT



Yes

No

Does a legal framework exist which accomodates SGE?

☐
☐

Is there a clear definition of the term "shallow geothermal energy"?

☐
☐

Are access rights/explotation rights cleary regulated?

☐
☐

Is the ownership of geothermal energy regulated?

☐
☐

Do legal regulations specify the documents representing the state of the art?

☐
☐

Are technical standards concerning SGE existing?

☐
☐

Are there technical aspects clearly defined and regulated?

☐
☐

Are binding quality checks defined for the installation (e.g., leakage tests)?

☐
☐

Is SGE design a certified or protected profession?

☐
☐

Are specific certificates for drillers and/or installers existing, which exceed standard professional licenses for drillers, well constructors or installers?

☐
☐

Does authority staff need specific certificates for the evaluation of application for shallow geothermal systems?

☐
☐

INTEGRATED MANAGEMENT



Need for change

The majority of currently existing systems is unbalanced – this means that the subsurface temperature changes are permanent. At the same time, common licensing procedures in Central Europe support a “first come - first serve” practice. In short, the full potential of geothermal energy is not achieved while economic and social interests are not sufficiently considered.

In contrast, a prudent and responsible resource management enables a sustainable and efficient utilization. An ideal integrated management concept considers all installations and their collective impact on subsurface conditions. It uses information gathered from existing installations during the planning stage of future installations.

Requirements for an integrated management concept are: Knowledge of the geothermal potential, a supportive legal framework, adequate quality standards, information regarding existing installations, and well-trained personnel.

The main objectives of integrated management are:

- Minimizing the impact of shallow geothermal energy use on the subsurface to prevent negative cumulative interaction effects;
- Preventing safety hazards, technical issues and environmental risks during the installation and operation phases;
- Enhancing and sustaining the efficiency of shallow geothermal energy use;
- Ensuring continuous access to information regarding resources and limitations of use (possible conflicts) associated with shallow geothermal energy use;
- Accelerating and simplifying licensing and communication routines between regulators and operators/applicants;
- Minimizing the costs for both regulators and operators.

GeoPLASMA-CE developed an integrated management approach which utilizes information from existing installations to achieve these main objectives. This cyclic management approach is based on the requirements stated above.

INTEGRATED MANAGEMENT



9

SELF ASSESSMENT

Yes

No

Are integrative management methods used?

☐☐

Are the targets of geothermal energy management clearly defined?

☐☐

Are routines and calculation schemes for system designs provided?

☐☐

Does information from existing installations feed back into the planning and licensing of new installations?

☐☐

INTEGRATED MANAGEMENT



The GeoPLASMA-CE integrated management approach is based on the following five principles:

Cyclic management is the most important principle for the management of shallow geothermal energy systems. The currently prevailing process can be thought of as a series of steps – planning, licensing, implementation and operation – which is executed in isolation for each system. The GeoPLASMA-CE management loop, however, implements monitoring and feedback schemes. Providing operational information to planners of new installations closes the process chain to form a feedback loop.

Completeness of information refers to the inclusion of existing shallow geothermal energy systems during the planning and licensing stages. Present regulations evaluate installations individually or include only installations in the near vicinity. This leads to a non-permitting policy in some countries where smaller installations do not even need to be notified to the authorities. A comprehensive knowledge of existing SGE is therefore not only a prerequisite for integrative management approaches; it is a necessity to avoid conflicts between individual installations.

Digital management facilitates access to information and communication between users and regulators. Examples are web-based information systems and online application forms. Open data access policies should be supported.

Integrated management includes summation effects and conflicts of use into local/ regional energy management plans. Integrated management depends on the provision of information. Point 1 “Cyclic management” and point 2 “Completeness of information” are indispensable prerequisites for an integrative management system.

Clear responsibilities: Procedures (e.g., application processes) should clearly define the tasks of users and administrative bodies. Responsibilities of the different authorities have to be unambiguous concerning their rights and duties, e.g., which authority issues recommendations and which authority may impose binding conditions.

PLANNING & DESIGN



Protected profession

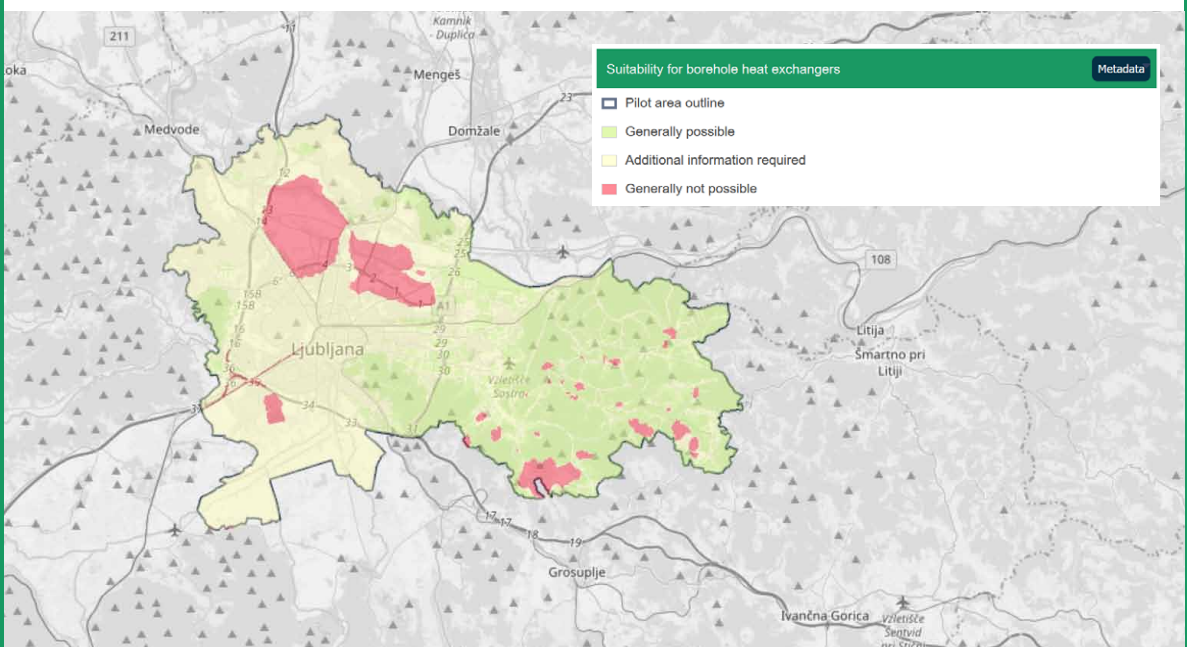
Shallow geothermal energy installations have to be designed within the legal framework and under consideration of all applicable quality standards. It is recommended to regulate and oversee personnel which plans and designs installations either through a certification scheme or by recognizing “Shallow Geothermal Energy – Planner” as a legally protected profession.

Local conditions

The design is based on information regarding local conditions. This information has to be accessible in a suitable format free of charge. Provision of reliable data eliminates the use of generalized literature values (i.e. thermal conductivity) and other approximations. It should be complemented by field measurements from the installation in question. Examples are Thermal Response Tests for closed-loop systems and pumping tests for open-loop systems.

Geological or hydrogeological conditions which could pose drilling hazards, such as faults or artesian conditions, have to be determined for each region. Conflict and suitability maps should be created and published. The potential impact of these drilling hazards has to be considered during the planning phase and should be reflected in appropriate precautionary measures.

11



PLANNING & DESIGN



Information requirements

The following maps represent the minimum requirement for information that should be available during the planning phase:

- Geological information;
- Contaminated areas;
- Hydraulic productivity;
- Groundwater chemistry;
- Outline of suitable aquifers;
- Artesian and confined aquifers;
- Water and nature protection zones;
- Mining and other subsurface cavities;
- Average thermal conductivity in suitable depth intervals;
- Relevant geological and hydrogeological risk factors;
- Separate suitability maps ("traffic light maps") for open-loop and closed-loop systems;
- Existing geothermal installations (if consistent with existing national data protection regulations).

12

SELF ASSESSMENT

Yes

No

Are technical state of the art standards provided by regulators in terms of legal acts, guidelines or handbooks?

☐☐

Do authorities provide consulting during the planning phase?

☐☐

Are routines and calculation schemes for system designs provided?

☐☐

Are any of the recommended maps provided?

☐☐

Is it mandatory to use the data provided by the information systems for the design of an SGE installation?

☐☐

LICENSING



Application procedure

Access to shallow geothermal energy is fostered by **one-stop-shop** application procedures, i.e. the applicant deals with only one single authority which then involves other authorities as required. A system for electronic submission of applications should be implemented.

Initiation of the application procedures should be independent of installation type and size, i.e. the applicant completes the same form for any project. Administrative licensing procedures, however, should distinguish between small, medium and large-scale installations. An example for a licensing procedure is shown on the following pages.

License

A license must include the official instructions for the installation, operation and monitoring of the installation and respective time spans for the execution. It is advisable to state fixed seasonal balances and the operational mode in the notification documents, as well as an expiry date for the license.

13

SELF ASSESSMENT

Yes

No

Does the use of SGE require always a permit?

☐☐

Has a one-stop-shop scheme been implemented?

☐☐

Does the authority provide online support (e.g., forms, guidelines)?

☐☐

Does the licensing authority provide a full electronic submission and communication system for applications?

☐☐

Is there a time limit specified for the duration of the licensing process?

☐☐

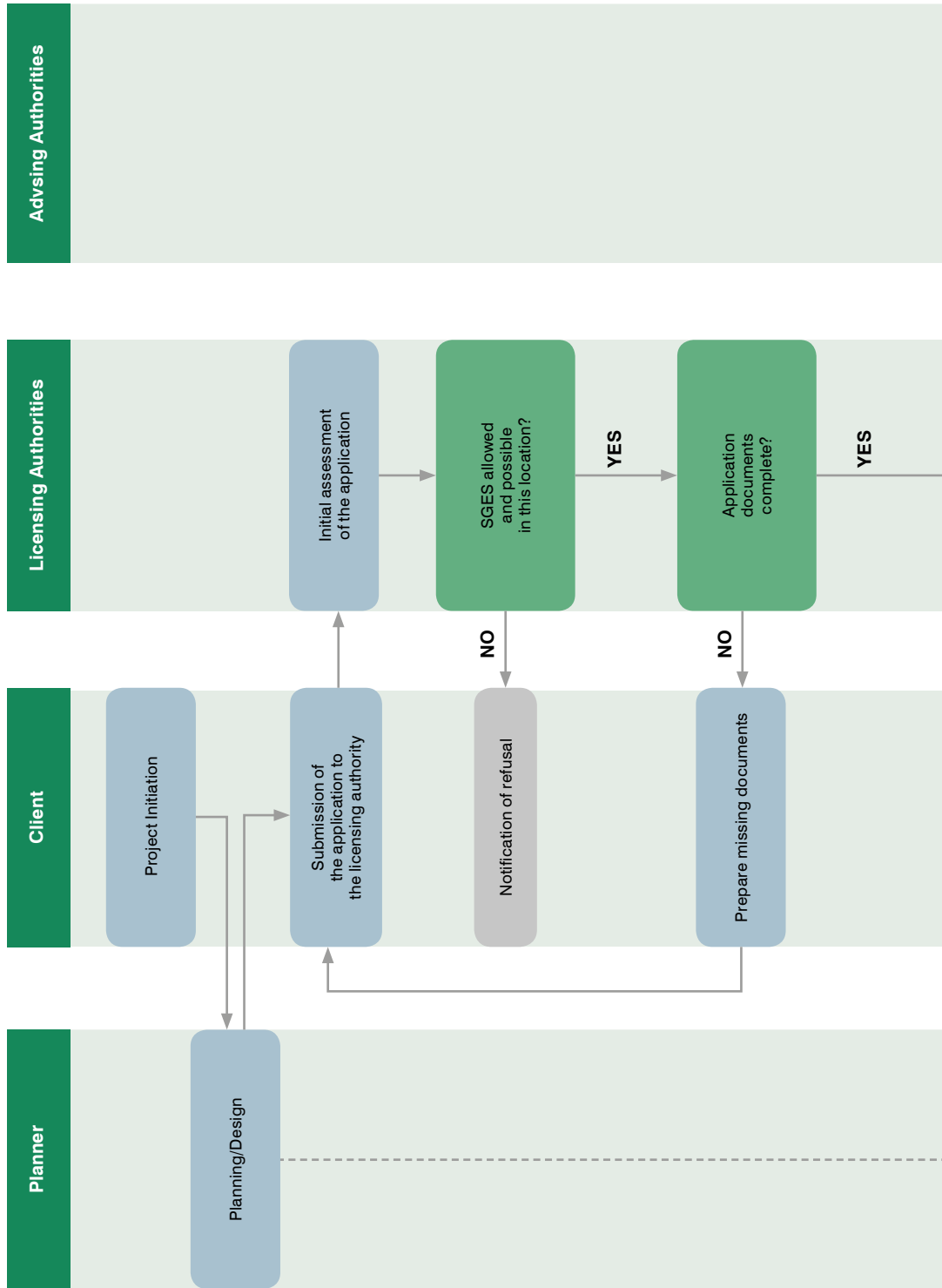
Are the operational licenses granted for a specified period of time?

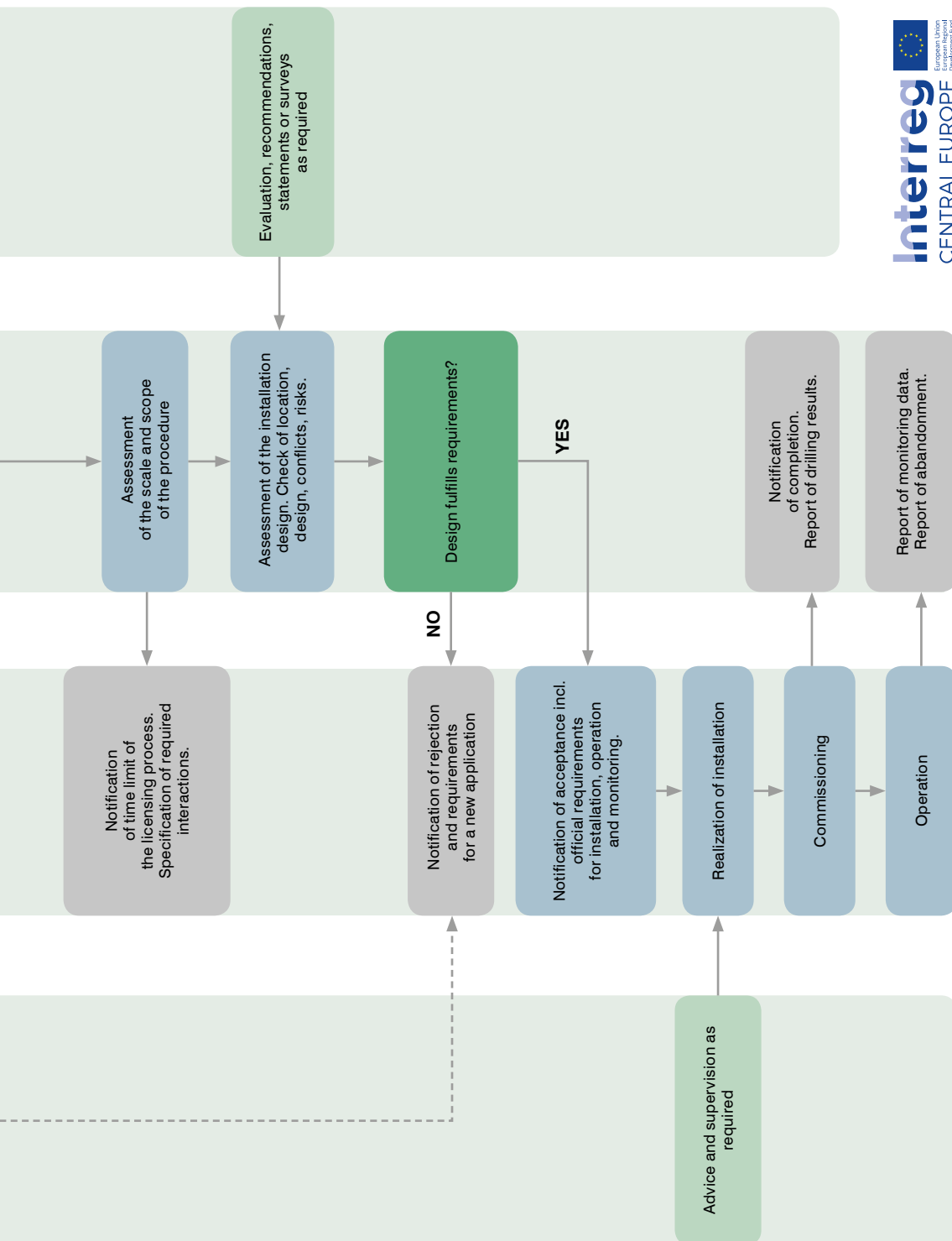
☐☐

Are licensed installations collected in registers (a cadastre)?

☐☐

LICENSING





INSTALLATION



The installation phase encompasses the **implementation and commissioning** of a SGE-system, including drilling, thermal response tests (TRT) or pumping tests, well-completion, pressure testing, connection to the heat pump, adjustment of operation parameters etc. up to the final inspection.

Each step has to be performed to a **high standard of quality** since issues related to the installation phase are usually very hard to rectify, and therefore expensive and time-consuming.

It should be mandatory to document the entire installation-stages for legal and quality assurance reasons. The required parameters should be specified and a form should be made available for providing the required information to the authorities. If a licensed installation is not implemented for any reason, the authorities should be notified.



16

SELF ASSESSMENT

Yes

No

Is it mandatory to document the drilling, installation and commissioning?

☐☐

Is it obligatory to report the accomplishment of the installation?

☐☐

Is the authority empowered to perform *in situ* quality checks during or after the installation?

☐☐

OPERATION



Regular service intervals and **maintenance** tasks should be defined and recommended or proscribed to owners of SGE installations and cover:

- Visual inspection for wear of mechanical parts;
- Measurement of working pressures in all fluid-filled lines;
- Check for trapped air or contaminants in the fluid system;
- Verification of correct antifreeze concentration (if applicable);
- Measurement and adjustment of volume flow.

For **closed-loop** systems, it should be mandatory to report leakage of heat-carrier fluids to the authorities. This obligation of the owner and the correct local contact details of the authorities should be stated in the license. Operating parameters such as peak and base load, minimum temperature etc. should be specified in the license.

For **open-loop** systems the licence should state operating parameters such as water extraction rates, minimum and maximum injection temperatures etc.

Authorities should verify compliance with the stipulations of the license and enforce it with appropriate measures.

Installation efficiency can be optimized by performing system efficiency monitoring.

SELF ASSESSMENT

Yes

No

Are technical standards existing how to use shallow geothermal systems in an efficient way (e.g., to use SGE for heating and cooling)?

☐
☐

Are regular service intervals and maintenance tasks defined in guidelines?

☐
☐

Is the obligation to report leakage of heat-carrier fluid as well as local contact details included in the permit or easily accessible online?

☐
☐

Is compliance with the legal regulations and stipulations of the permit verified and enforced by the authorities?

☐
☐

Is compliance with legal regulations and stipulations fostered by regular reporting of operational data to the licensing authorities?

☐
☐

ABANDONMENT



End of lifecycle

Taking an SGE installation permanently out of service will have an impact on the subsurface temperature distribution. Abandonment of an installation has to be notified to the authorities.

Abandonment procedures have to be standardized. It is recommended that standards deal with the removal of surface equipment such as well head, tubing etc., and with securing the well-location. The heat carrier fluid has to be removed from closed-loop systems. Conversion of open-loop systems into observation wells should be considered. Any remaining tubes have to be filled with cement to prevent adverse impact on ground water and avoid the formation of subsurface cavities due to collapsing pipes.

18

SELF ASSESSMENT

Yes

No

Is it mandatory to abandon an SGE installation after the end of the operational time?

☐☐

Is abandonment defined in legally binding documents?

☐☐

Do the authorities have to be notified of decommissioning or abandonment?

☐☐

Are there binding technical guidelines which detail the abandonment procedure?

☐☐

Are there technical standards defined in guidelines and handbooks for the liquidation of SGE systems?

☐☐

Is the decommissioning or abandonment notification used to update the information system and adjust the environmental monitoring schedule?

☐☐

MONITORING



It is recommended to group open-loop and closed-loop installations into three categories each based on peak load. System efficiency monitoring and environmental impact monitoring schemes have to be specified for each category. Recommendations are shown in the **"Guide for quality standards"**.

Firm guidelines will advise local authorities on:

- Circumstances in which monitoring is to be mandated;
- The monitoring parameters, intervals and time period to be mandated, under consideration of environmental setting, potential impact and installation type;
- Criteria for the extension of existing licenses;
- Specifications of suitable observation wells.

System efficiency monitoring should be performed for at least three years and environmental monitoring until the installation is decommissioned.

SELF ASSESSMENT

Yes

No

Are technical standards related to monitoring?

☐☐

Do guidelines recommend system efficiency monitoring for at least 3 years to all SGE operators?

☐☐

Are there detailed guidelines which advise the licensing authorities in which circumstances they have to mandate monitoring, and which parameters, intervals and time periods should be proscribed?

☐☐

Does the scope of monitoring activities depend on installation type and installation size (peak load)?

☐☐

Is there a binding definition for "suitable observation well"?

☐☐

Are there any guidelines detailing the collection and interpretation of environmental impact monitoring data?

☐☐

Is collection and interpretation of environmental impact monitoring data performed by the authorities or independent third parties?

☐☐

INFORMATION SYSTEM



Comprehensive information regarding the scientific description of the subsurface, legal and spatial planning considerations should be provided in a single, publicly accessible web portal free of charge. The information system should be linked to an online application system.

Data has to be factually correct and current. Contents should be revised in regular intervals specified for each individual data set depending on its time sensitivity. The information system should allow the execution of location-specific queries. Access levels should be defined in compliance with national regulations, in particular concerning data protection. A system for user registration and identification should be implemented. Restricted data should be provided upon request and limited in extent to those persons who demonstrate a vested interest (planners, owners).

SELF ASSESSMENT

Yes

No

Is a web-based information system available free of charge?

☐☐

Does the information system allow location-specific queries?

☐☐

Is it linked to an online application system?

☐☐

Does the information system contain installation-specific data such as location, depth and capacity?

☐☐

Are monitoring data used to update web-based information systems or publicly accessible datasets?

☐☐

Has an appropriate method for collecting privately owned monitoring data been established?

☐☐

Are different access levels implemented?

☐☐

Is access to the information system monitored to identify and prevent misuse, unauthorized access and data manipulation?

☐☐

GUIDE FOR QUALITY STANDARDS



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European Regional
Development Fund

GeoPLASMA-CE

QUALITY STANDARDS FOR CLOSED-LOOP SYSTEMS

Basis of design

Material parameters used for CLS installation design should be specified.

Small-scale to medium-scale installations should be designed based on archive data, best experience and available guidelines. Medium-scale to large-scale installations should be designed based on thermal response tests (TRT) and numerical simulations.

TRT improve depth requirement calculations and/or validate models. TRT measurements are recommended for medium and large-scale installations. Minimum shutdown period and minimum test duration should be specified in guidelines.

Numerical simulations

Numerical simulations help determining the interactions of the planned installation with the surrounding subsurface and neighbouring installations. They should be mandatory for medium and large-scale closed-loop installations.

A simplified analytical approximation of the propagation of thermal changes should be performed prior to the numerical simulation in order to determine the necessary size of the modelling area. Existing installations must be considered if a mutual influence can be expected. The size of the modelling area should be sufficiently large to prevent boundary effects.

The numerical simulation should be based on a steady-state coupled thermal-hydraulic model covering the planned operation period of the installation. The simulation should reflect the planned annual energy extraction/injection rather than short-term peak loads. Validation of the numerical model based on operational monitoring data should be mandatory for large-scale installations and recommended for medium-sized installations. The observation period should cover at least the first 3 years of operation.

Minimum distances between Borehole Heat Exchangers (BHE)

BHE alter the temperature of their subsurface environment and thus potentially influence the efficiency of neighbouring installations. A precautionary approach considers neighbouring installations, the environmental circumstances and the energy demand of all installations during the planning phase. Influences are to be excluded by specifying a suitable minimum distance (e.g., 10% of BHE depth). For medium and large-scale installations, a numerical simulation should be mandatory if mutual influence is expected.

GeoPLASMA-CE recommends specifying the acceptable impact on the temperature conditions of neighbouring installations in legally binding documents.

Temperature of the heat carrier fluid

The temperature of the heat carrier fluid shall be selected to obtain a sustainable and efficient use. Excessively high heat extraction rates generate low soil/rocks temperatures, creating the risk of freezing, soil subsidence and low system efficiency.

Critical temperature values and operation limits for peak load and average throughout the heating period should be specified in technical guidelines. Expected temperature of the heat carrier fluid at the end of the installation's lifetime should be calculated. This temperature should exceed 4°C to prevent freeze-thaw cycles.

Borehole drilling report and sampling

Lithological and other information may be collected by the authorities and is important for quality control (system design and efficiency) and environmental control. Cutting samples serve as proof that the dimensioning based on thermal conductivities is appropriate. Completion of a geological report should be mandatory for all installations irrespective of installation type or size. The geological report should contain as a minimum a lithological profile in compliance with national standards, drilled groundwater tables and the completion scheme.

Regulations for the grouting of borehole heat exchangers

Grouting has to be designed with the purpose to preserve groundwater quality, natural hydraulic conditions (separation of groundwater storeys), groundwater regime and circulation, and to optimize heat transfer to the BHE. Resistant grouting material is required in the presence of cement corrosive waters.

Cementation of the entire length of the BHE should be mandatory in all geological environments with significant groundwater occurrence. In addition, quality control measures should be implemented.

Leakage test of ground loop and refrigerant tubing

A leakage test highlights issues with the correct installation and functioning of equipment. It minimizes adverse impact on the environment and can prevent high follow-up costs and/or reduced efficiency of the system.

Leakage tests during the installation phase should be mandatory for all BHE systems. They should be performed with a non-hazardous fluid prior to filling the system with heat carrier fluid. Test conditions have to be specified in binding guidelines. If the fluid is a material hazardous to groundwater, appropriate control measures have to be implemented and appropriate training has to be provided to personnel.

Monitoring

In the absence of pre-defined conditions or concerns, all environmental impact monitoring (EIM) or system efficiency monitoring (SEM) should be performed on a voluntary basis, irrespective of installation size.

QUALITY STANDARDS FOR OPEN-LOOP SYSTEMS

Groundwater analysis

Groundwater analysis helps choosing the correct equipment and preventing adverse effects on the installation, such as scaling or metal corrosion. It is recommended for all installations where the groundwater composition is unknown.

It is also recommended to create and publish data layers showing groundwater bodies with problematic groundwater chemistry.

Pumping test

A pumping test verifies that the system design is suitable for the available groundwater body and allows calculation of the hydraulic conductivity.

The required yield must be confirmed and it has to be proven that the produced water can be re-infiltrated into the aquifer without adverse impact. Pumping and reinjection tests should be mandatory for medium and large scale OLS installations; also for small scale installations if there is no prior knowledge about the aquifer.

Results of pumping tests should be collected by the responsible authorities and should be publicly available.

Negative impact on neighbouring installations

Negative impact on neighbouring installations can be characterised by temperature changes, drawdown and in rare cases by rise of groundwater. Impact depends on the individual conditions and can be quantified by simulations in combination with long-term monitoring. It is recommended to specify the acceptable impact on neighbouring installations in legally binding documents. The specifications can be based on groundwater temperature, drawdown/build-up and reduction in installation output or a combination thereof.

Minimum distances to existing installations or between a pair of extraction/injection wells have to be determined according to natural (subsurface) conditions, energy demand and the assessment of neighbouring SGES during the planning stage.

Temperature of reinjected water

Temperature changes can alter geochemical and ecosystem conditions and increase activity of bacteria and micro-fauna, which may decrease the groundwater quality.

A maximum permissible temperature difference between extracted and reinjected groundwater should be specified. The license should state the maximum thermal work per year for both heating and cooling.

In areas with a high density of installations, it is recommended to implement a comprehensive subterranean heat management and link maximum allowed temperature shift to groundwater temperature maps. In heavily used groundwater bodies, it is recommended to specify maximum allowable temperature levels based on assessment of microbiological conditions.

It is recommended to specify absolute temperature limits for reinjected groundwater. The minimum temperature should be higher than 4°C and the maximum temperature limits should consider national requirements for drinking water.

Numerical simulations

Numerical simulations help determining the interactions of the planned installation with the surrounding subsurface and with neighbouring installations. They should be mandatory for medium and large-scale open-loop installations.

A simplified analytical approximation of the propagation of thermal plumes in groundwater bodies should be performed prior to the numerical simulation in order to determine the necessary size of the modelling area. Existing installations must be considered if a mutual influence can be expected.

The size of the modelling area should be sufficiently large to prevent boundary effects to the simulated plumes.

The numerical simulation should be based on a steady-state coupled thermal-hydraulic model covering the planned operation period of the installation. A calculation of the required amount of water (hydraulic productivity) has to be done based on the heating and cooling demand. The simulation should reflect the planned annual energy extraction/injection rather than short-term peak loads.

Validation of the numerical model based on operational monitoring data should be mandatory for large-scale installations and recommended for medium-sized installations. The observation period should cover at least the first 3 years of operation.

Reinjection of used groundwater

Reinjection of groundwater prevents depletion of the aquifer but bears the risk of contamination. Temperature changes will be observed in the groundwater which could lower the efficiency of geothermal wells located downstream. Given the right hydrogeological conditions, reinjection could also allow using the aquifer as seasonal temperature storage.

It is recommended to specify reinjection into the same groundwater body as the preferred method. In case of low hydraulic conductivities or low overburden thickness above the groundwater table, horizontal injection wells should be erected. It is recommended to limit the application of soakaways to small-scale installations producing from the topmost aquifer with sufficiently shallow groundwater table.

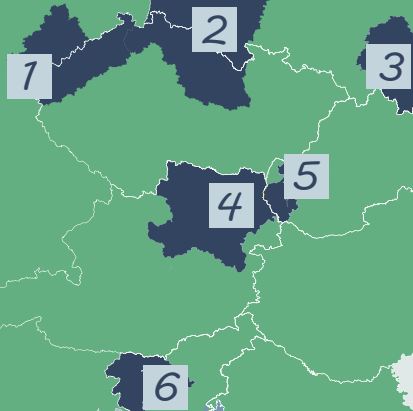
Monitoring

Certain minimum requirements for environmental impact monitoring (EIM) and system efficiency monitoring (SEM) should be mandatory.

GeoPLASMA-CE recommended monitoring for open-loop systems

Bold and italic written actions should be mandatory; Normal written actions concern voluntary monitoring

	Small-scale	Medium-scale	Large-scale
	<12 kW (Single-family house)	12-50 kW (Multi-family house)	>50 kW (Commercial building)
EIM	<i>Initial water analysis</i> Bi-annual water analysis Analog electricity meter Operating hours	<i>Initial water analysis</i> Bi-annual water analysis Mass flow Electronic electricity meter	<i>Initial water analysis</i> Bi-annual water analysis Mass flow Full monitoring system
SEM	<i>Annual volume pumped</i> <i>Temp out</i> <i>Temp in</i> 2-4 temp profiles per year (downstream)	<i>Annual volume pumped</i> <i>Temp out</i> <i>Temp in</i> 2-4 temp profiles per year (downstream)	<i>Annual volume pumped</i> <i>Temp out</i> <i>Temp in</i> 2-4 temp profiles per year (upstream & downstream)



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PARTNERS

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REGIONS

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COUNTRIES

2.9

MILLION EURO
PROJECT
BUDGET

2.4

MILLION EURO
ERDF

TAKING
COOPERATION
FORWARD

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Editorial deadline: June 18th, 2019

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Photograph: p.16 – Installation of borehole heat exchanger © Brugeo project

Graphics: all graphics and tables © GeoPLASMA-CE project

Layout and printing: Polish Geological Institute – National Research Institute

Disclaimer:

This document was prepared by the Interreg IV project “GeoPLASMA-CE: Shallow Geothermal Energy Planning, Assessment and Mapping Strategies in Central Europe”.

This report intends to give an overview of issues associated with shallow geothermal energy management. It does not imply approval by legal authorities. The editors and project partners do not take any liability for damages caused by inappropriate use of the contents presented.

ISBN 978-83-66423-64-0



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