Managing Urban Shallow geothermal Energy
Project number GeoE.171.006

Deliverable 3.1

Report on the current legal framework, procedures and policies on SGE use in selected European cities

Authors and affiliation:
Maciej R. Kłonowski[1]
Olga Lipińska[1]
Mateusz Żeruń[1]
Jacek Kocyła[1]
Monika Konieczyńska[1]
Grzegorz Ryżyński[1]
Alejandro García-Gil[2]
Gregor Goetzl[3]

[1]Państwowy Instytut Geologiczny - Państwowy Instytut Badawczy, PIG-PIB
[2]Instituto Geológico y Minero de España, IGME
[3]Geological Survey of Austria, GBA
e-mail of lead author:
maciej.klonowski@pgi.gov.pl
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General description of the task in the application form

Task 3.1 Current legal status, procedures and policies dealing with SGE use (PIG-PIB):

In a first step, we assess the current legal framework, procedures and policies in the pilot areas as well as on the EU level through an internal partner survey. This survey also addresses the role of national geological surveys in the management process. Previous compilations of the legal framework for shallow geothermal use in different member states (e.g. projects ReGeoCities, GRETA and GeoPLASMA-CE) will be included in the assessment. In a second step, we apply an evaluation.

General description of the deliverable in the detailed work plan

Deliverable D.3.1 Report on the current legal framework, procedures and policies on SGE use in selected European cities

The report will showcase and compare regulation and incentive measures for SGE use in the investigated European cities. It will highlight existing gaps, deficiencies as well as good practices, and will give proposals in regard to resource ownership, licensing systems (e-government) as well as simplified regulations and administrative procedures.

Involved MUSE team including preparation of the partners' questionnaires

Project partner	People in charge
Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy, PIG-PIB, P13	*Maciej R. Kłonowski* *Olga Lipińska* *Mateusz Żeruń* *Jacek Kocyła* *Monika Konieczyńska* *Grzegorz Ryżyński*
Instituto Geológico y Minero de España, IGME, P10	*Alejandro García-Gil*
Geological Survey of Austria, GBA, P01	*Gregor Goetzl*
Natural Environment Research Council, NERC-BGS, P02	*Gareth Farr, David Boon*
Hrvatski Geološki Institut, HGI-CGS, P04	*Staša Borović*
Česka Geologicka Služba – Czech Geological Survey, CGS, P05	*Jan Holeček*
Bureau de Recherches Géologiques et Minières, BRGM, P06	*Camille Maurel*
Geological Survey Ireland, GSI, P07	*Natalya Hunter Williams*
Royal Belgian Institute of Natural Sciences – Geological Survey of Belgium, RBINS-GSB, P08	*Estelle Petitclerc*
Geološki zavod Slovenije, GeoZS, P09	*Mitja Janža*
Sveriges Geologiska Undersökning, SGU, P11	*Mikael Erlström*
Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek TNO, P12	*Stefan Carpentier*
State Geological Institute of Dionyz Stur, SGIDS, P14	*Radovan Černak*
Geological Survey of Denmark and Greenland, GEUS, P16	*Claus Ditlefsen*

List of project partners

Project partner #	Project partner – name and acronym	Country	Country code*
P01	Geologische Bundesanstalt, GBA	Austria	AT
P02	Natural Environment Research Council, NERC-BGS	United Kingdom	UK
P03	Institut Cartogràfic i Geològic de Catalunya, ICGC	Spain / Catalonia	ES / CT
P04	Hrvatski Geološki Institut, HGI-CGS	Croatia	HR
P05	Česka Geologicka Služba – Czech Geological Survey, CGS	Czech Republic	CZ
P06	Bureau de Recherches Géologiques et Minières, BRGM	France	FR
P07	Geological Survey Ireland, GSI	Ireland	IE
P08	Royal Belgian Institute of Natural Sciences – Geological Survey of Belgium, RBINS-GSB	Belgium	BE
P09	Geološki zavod Slovenije, GeoZS	Slovenia	SI
P10	Instituto Geológico y Minero de España, IGME	Spain	ES
P11	Sveriges Geologiska Undersökning, SGU	Sweden	SE
P12	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek TNO	The Netherlands	NL
P13	Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy, PIG-PIB	Poland	PL
P14	State Geological Institute of Dionyz Stur, SGIDS	Slovakia	SK
P15	State Research and Development Enterprise State Information Geological Fund of Ukraine, GEOINFORM	Ukraine	UE
P16	Geological Survey of Denmark and Greenland, GEUS	Denmark	DK

P – project partner

*In this report the country code is always understood as two-letter ISO 3166-1 Alpha-2 code

List of abbreviations and acronyms

Abbreviation,	Full name
ATES	Aquifer Thermal Energy Storage
BTES	Borehole Thermal Energy Storage
BHE	Borehole Heat Exchanger
CLS	Closed-Loop System
COP	Coefficient of Performance
DHW	Domestic Hot Water
EGEC	European Geothermal Energy Council
ETIPs	European Technology and Innovation Platforms
EC	European Commission
EU	European Union
FP7	7th Framework Programme for Research and Technological Development
GMI	Geothermie de Minime Importance
GER	Geothermal Energy Resources
GSHP	Ground Source Heat Pump
GSO	Geological Survey Organisation
GWHP	Groundwater Heat Pump
GWD	Groundwater Directive
H&C	Heating and Cooling
Horizon 2020	Horizon 2020 EU Research and Innovation Programme
IEE	Intelligent Energy Europe
IRENA	International Renewable Energy Agency
LCC	Life Cycle Costing
MoE	Ministry of the Environment
NGO	Non-Governmental Organization
NREAPs	National Renewable Energy Action Plans
OLS	Open-Loop System
NSGE	Near Surface Geothermal Energy
RBMP	River Basin Management Plan
RED II	Renewable Energy Directive II
RES	Renewable Energy Sources
RH&C	Renewable Heating and Cooling
SEAPs	Sustainable Energy Action Plans
SET Plan	Strategic Energy Technology Plan
SGE	Shallow Geothermal Energy
SGES	Shallow Geothermal Energy System

TRT	Thermal Response Test
WFD	Water Framework Directive

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1 INTRODUCTION

The European Union is a leading actor in global activities connected with climate and energy policy. During the recent decades significant steps forward have been made in order to meet the requirements of such international agreements as the **Kyoto Protocol** (1997) and **Paris Agreement** (2015, COM(2016) 110 final) and the respective strategies and legal regulations on the EU level. Special attention has been paid to mitigation of climate change by means of reduction of greenhouse gases and suspended dust emission into the atmosphere in Europe (Maione et al. 2016, Wachsmuth and Duscha 2019, Duscha Denishchenkova, Wachsmuth 2019). Following these activities, the dedicated EU strategies, such as **EU 2020 Energy Strategy** (COM(2010) 639 final), **European Energy Security Strategy** (COM(2014) 330 final), **EU 2030 Energy Strategy** (COM(2014) 15 final, COM(2014) 520 final), **Energy Union** (COM(2015) 80 final), **Energy Roadmap 2050** (COM(2011) 885 final), **Clean Energy for all Europeans package** (COM(2016) 860 final), **The European Green Deal** (COM(2019) 640 final, Bouzarovski et al. 2020) which include the regulatory legislative framework, public awareness campaigns, scientific research, etc. has been elaborated and put in force.

The above mentioned EU strategies connected with climate and energy policy take into account, to some extent, application of shallow geothermal energy (SGE), also called low-temperature, low-enthalpy or near surface geothermal energy (NSGE). The positive role of SGE, which is a renewable energy source (RES), in mitigating the climate change and enhancing the decarbonisation concept shall be continually enhanced, while application of SGES needs to be encouraged by the strategies and action plans on the EU and member state's level.

This report refers to the selected SGE use and applications which should be regarded as a part of geothermal heat – one of the compartments of the concept of ambient thermal energy (Fig. 1). SGE is a safe modern technology which contributes to mitigation of smog and low emissions (Bayer 2012, Giambastiani 2014), especially when associated with renewable electricity sources. It is a reliable source of geothermal energy used for space heating and cooling (H&C) through application of diverse novel technologies of ground-coupled heat pumps. Those include closed-loop systems (CLS) exploited with help of ground source heat pumps (GSHP), (Lucia et al. 2017; Self, Reddy, Rosen 2013; Sarbu, Sebarchievici 2014; Yang, Cui, Fang 2010;) and open-loop systems (OLS) exploited with help of groundwater heat pumps (GWHP) (Abesser 2010; Banks 2012). In case of OLS the main heat source is the groundwater which is extracted via the groundwater wells. The SGE resources are normally exploited as a well doublet including an extraction and injection well or an array of those. In case of CLS, the heat exchangers are placed underground. There are several types of heat exchangers, among which the most common are borehole heat exchangers (BHE), horizontal loops, compact forms of ground heat exchangers, e.g. spiral, thermo-active building foundation structures, etc.

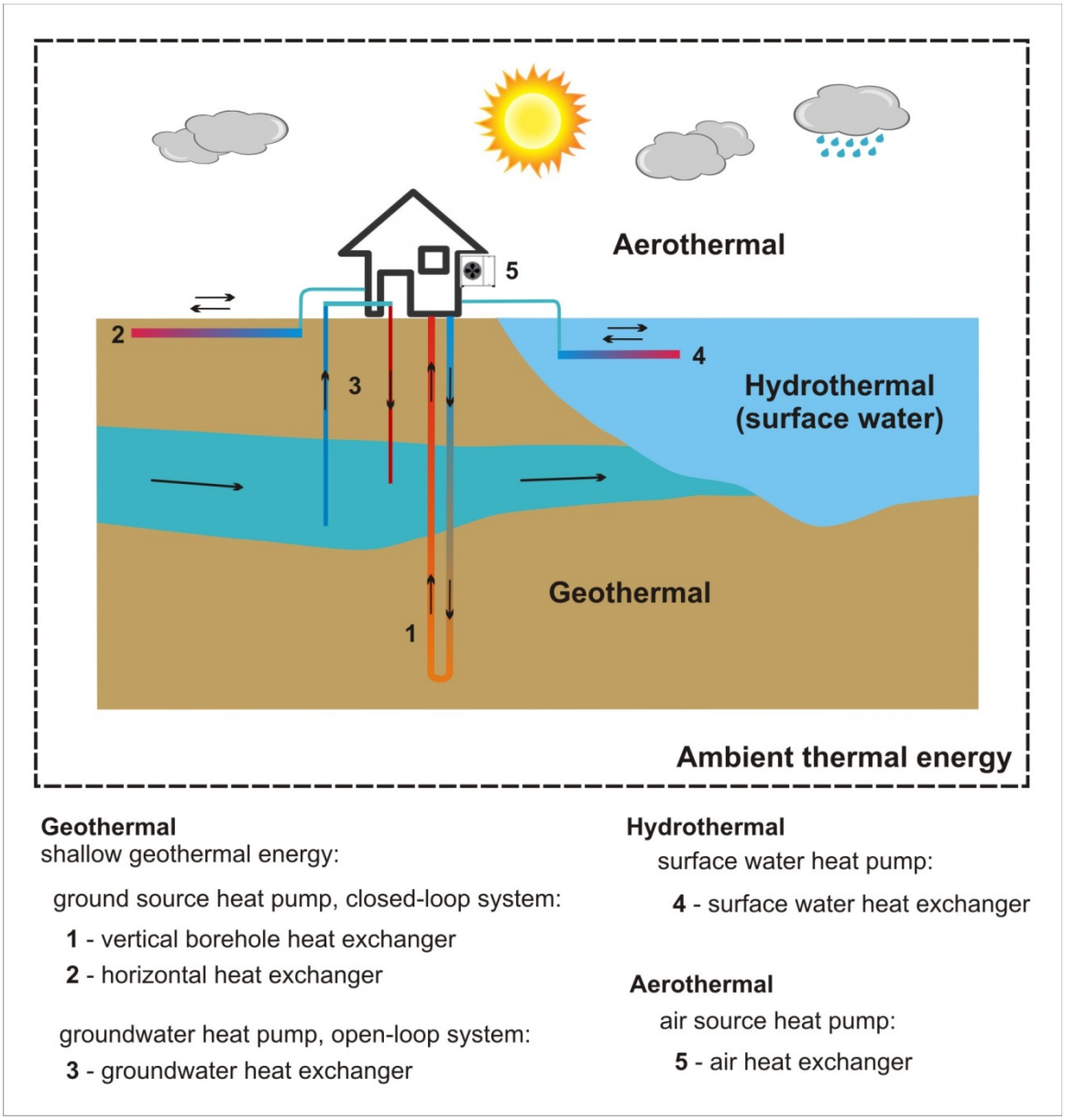


Fig. 1 SGE as a part of ambient thermal energy concept

2 GENERAL DESCRIPTION OF DELIVERABLE

The deliverable D.3.1 *Report on the current legal framework, procedures and policies on SGE use in selected European cities*, has been accomplished as one of the results of the Work Package 3 (WP3) entitled *Management strategies and action plans for a sustainable and efficient use of shallow geothermal energy*, under the terms of:

- task T.3.1 *Current legal status, procedures and policies dealing with SGE use*;
- detailed action T.3.1.1 *Assessment of the legal framework in the participating countries*;
- Project partner questionnaire *Partner survey on specific national legal framework, procedures and policies (questionnaire covering aspects reviewed in 3.1.1) including the role of geological surveys*.

The deliverable D.3.1 has been elaborated by the MUSE team of the following project partners: the Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy (PIG-PIB) with input from the Instituto Geológico y Minero de España (IGME) and Geologische Bundesanstalt (GBA). First of all, the attention was paid to collect the most relevant materials, including the EU directives, communications and other legal documents, scientific papers, literature and the outputs of the EU projects, for further analysis. A considerable part of the deliverable D.3.1 is based on the contributions from 14 project partners – geological survey organisations (GSOs), who responded to two questionnaires circulated among the project partners in 2019 and 2020. During elaboration of the summary report in spring 2020, the partners' comments to the final draft of the deliverable, including the appendices, were taken into account.

The deliverable D.3.1 *Report on the current legal framework, procedures and policies on SGE use in selected European cities* consists of the following parts:

- Summary report: *Report on the current legal framework, procedures and policies on SGE use in selected European cities,* along with analysis of the replies to the *Partner survey on specific national legal framework, procedures and policies (questionnaire covering aspects reviewed in 3.1.1) including the role of geological surveys*;
- Appendix IA Results of partners' questionnaire, part A, closed questions: Legal regulations and licencing procedures on CLS;
- Appendix IB Results of partners' questionnaire, part A, closed questions: Legal regulations and licencing procedures on OLS;
- Appendix II Results of partners' questionnaire, part B, Flowcharts for licensing procedures on SGE in the pilot areas;
- Appendix III Results of partners' questionnaire, part C, Specific geological and geographic conditions limiting SGES;
- Appendix IV Results of partners' questionnaire, part D, Regulation elements for SGES installation, implementation and operation;
- Appendix V Results of partners' questionnaire, part E, Register and monitoring of SGE installations.

3 AIM AND SCOPE OF THE REPORT

This summary report aims at analysing the current legal and administrative framework with respect to SGE use at the EU level as well as in the project partner countries, including the selected cities which are the project pilot areas. It provides a comprehensive summary of the EU energy policies, strategies, relevant documents and initiatives influencing development of SGES. The report also analyses the relevant regulations and procedures on the national, and if applicable, on the regional and local level as well. The report provides a thorough review of the results of the questionnaire *Partner survey on specific national legal framework, procedures and policies including the role of geological survey organisations* (GSO).

The report shows and compares the pertinent legal regulations, administrative procedures and incentive measures for SGE development in the investigated European countries and cities (pilot areas). It highlights the applicable guidelines and good practices as well as identifies existing gaps and deficiencies with respect to SGE use and development of the SGE market. In addition, it proposes new solutions, including simplified regulations and administrative procedures, with regard to the resource ownership, licensing systems, SGE installation register, facilitating measures on SGE application procedures, monitoring, etc. In this context, the report provides an analysis and compilation of the outcomes of the partners' questionnaire and builds upon the results of the selected relevant completed and ongoing European projects, i.e. ReGeoCities, progRESsHEAT, STEP UP, GRETA, GeoPLASMA-CE, HRE4 and DeCarb.

4 MATERIALS AND METHODS

Research activities pursued within the deliverable D.3.1 focused on studies of:

- the EU's policies and strategies on climate and energy;
- the EU's legal framework and regulations on SGE use;
- the outcomes of the relevant EU research and structural projects;
- the general concepts of the SGE management;
- the partners' replies to the questionnaire.

4.1 Analysis of EU legal framework, policies and strategies

The authors analysed development of a concept of energy management as a part of energy and climate policy with respect to RES and SGE. The key EU policies, strategies, documents and initiatives referring to SGES within the recent decades have been identified. Special attention has been paid to the requirements imposed on the EU member states by the subsequent programmes including the **EU 2020 Energy Strategy** (COM(2010) 639 final), **European Energy Security Strategy** (COM(2014) 330 final), **EU 2030 Energy Strategy** (COM(2014) 15 final, COM(2014) 520 final), **Energy Union** (COM(2015) 80 final), **Energy Roadmap 2050** (COM(2011) 885 final), **Clean Energy for all Europeans package** (COM(2016) 860 final), **The European Green Deal** (COM(2019) 640 final, Bouzarovski et al. 2020). The primary EU legal documents, such as **Renewable Energy Directive** 2009/28/EC, also called the RES Directive, **Energy Efficiency Directive** 2012/27/EU and the **recast of the Renewable Energy Directive** 2018/2001/EU, also called the RED II Directive, have been investigated with respect to SGE application. In addition, the authors investigated activities of the agencies supporting implementation of RES and SGES, i.e. **European Geothermal Energy Council** (EGEC) and European Technology and Information Platform on **Renewable Heating and Cooling** (ETIP RH&C) as well as the results of the key EU projects. In terms of the general concepts of the SGE management, the authors referred to the approaches and concepts described in literature and especially to the attainment of the deliverable D.3.2 of MUSE entitled *Guideline for integrating and managing the use of SGE in urban areas*.

4.2 Construction of partner questionnaire and feedback analysis

The idea of the partners' questionnaire and the template itself build upon the experience and results of the GeoPLASMA-CE project. The MUSE questionnaire, parts A, B, C and D, referring to the current status of the SGE use with emphasis on the legal framework and administrative regulations on the national level, and when applicable also regional and local (pilot area) level, was circulated among all project partners in 2019 and beginning of 2020. After analysing the results it became evident that a better insight into some SGE related issues was still required, therefore an additional questionnaire, further on referred to as part E, was circulated among the project partners in June 2020.

The individual questions in the questionnaires are grouped in parts A to E and the respective thematic areas. The general structure and content of the partner questionnaire, parts A, B, C, D and E, are presented in Tab. 1, while the exact questions are given in Tab. 2 – Tab. 5 and in the Appendices IA, IB, III, IV and V.

Tab. 1 General structure of the project partner questionnaire

#	Parts of the questionnaire and thematic areas
A*	Legal regulations and licensing procedures
A.1	Definition of SGE
A.2	Regulations on use of SGE
A.3	Application for SGES installations and licensing (permitting)
A.4	Authorities responsible for assessing applications and granting licenses (permits) for SGES installations
A.5	Requirements for operation of SGES
A.6	Special requirements for installation and operation of SGES
A.7	Decommissioning of the redundant boreholes used for SGES
A.8	Monitoring of SGES
B*	Flowcharts showing procedures and regulations for assessing applications and granting licenses (permits) on SGES
C*	Special geological and geographical conditions which can limit the installation of SGES
D*	Regulation elements for the installations, implementation and operation of SGES
E**	SGE register and monitoring
E.1	Comprehensive register of SGE installations / systems
E.2	Monitoring of SGE installations / systems
E.3	Environmental monitoring of SGE installations / systems

*circulated in 2019-2020

**circulated in June 2020

Part A

Part A comprises a series of 26 closed questions and the open question grouped in 8 thematic areas which are presented in Tab. 2 and the Appendices IA and IB. The possible replies to the closed questions are: *yes*, *no*, *case to case decision* and *decision up to regional regulations*. Results of the analysis supplied by the partners to the closed questions of the Part A are illustrated in the appendices IA and IB, referring to CLS and OLS, respectively, while the results of analysis of the replies to the open questions are described further down in the text.

Tab. 2 List of closed questions of the partner questionnaire, part A.1 - A.8

#	Question*
A.1	**Existing legal definition of SGE (CLS and OLS)**
A.2	**Regulations on use of SGE** **Is your GSO involved in legislation on use of SGE referring to the following aspects:**
A.2.1	GSOs involved in law and legal regulations enforcement
A.2.2	GSOs involved in controlling
A.2.3	GSOs involved in legal consulting
A.2.4	GSOs involved in assessment of legal regulations
A.2.5	GSOs involved in influencing improvement of existing legislation and development of new legislation
A.3	**Application for SGES installations and licensing (permitting)**
A.3.1	Is the official application for SGES installation and their further use legally regulated and obligatory?
A.3.2	If yes, do the legal regulations on SGES comprise also licensing (permitting) procedures?
A.3.3	Are the application procedures the same for the whole country?
A.3.4	Are the application procedures the same for all the applicants (for example institutional vs. individual applicants)?
A.3.5	Is there any electronic (online) application procedure available?

#	Question*
A.3.6	Is duration for proceeding of the SGES applications and granting the licenses (permits) legally regulated?
A.3.7	Is the GSO involved in assessing and/or proceeding the SGES applications?
A.3.8	Is the GSO involved in granting the licensees (permits)?
A.3.9	Is the land owner the only owner and user of the SGE resources?
A.3.10	Is the length of the license (permit) legally regulated?
A.3.11	Are there any fees connected with assessment and proceeding of SGES applications?
A.3.12	Are there any fees connected with granting the license (permit) for SGES applications?
A.4	**Authorities responsible for assessing applications and granting licenses (permits) for SGES installations**
A.4.1	Do the responsible authorities offer the applicants any information and/or support while submitting the SGES applications?
A.5	**Requirements for operation of SGES**
A.5.1	Is operation of SGES legally regulated?
A.5.2	Is any controlling of SGES operation required?
A.5.3	If yes, is the GSO involved in the controlling procedure?
A.6	**Special requirements for installation and operation of SGES**
A.6.1	Are the requirements concerning installation and operation of SGES in case of the pilot area (local level) different than in case of the national level?
A.7	**Decommissioning of the redundant boreholes used for SGES**
A.7.1	Is decommissioning of the redundant boreholes legally required?
A.8	**Monitoring of SGES**
A.8.1	Is monitoring of SGES legally required?
A.8.2	Is monitoring of SGES commonly applied?

*partner questionnaire run in 2019-2020

Part B

Part B comprises a request to draw a simplified flowchart, with help of the ready-made elements (text boxes and arrows), showing the administrative procedures and regulations in the context of a legal framework for both CLS and OLS. The flowchart is meant to illustrate the national implementation of SGES and the specific regulations in the countries and pilot areas. The style is based upon the flowcharts designed in the GRETA project and thereafter implemented in the GeoPLASMA-CE project. Space for additional comments and explanations is provided under the flowchart. The resulting portfolio of the flowcharts illustrating the situation in the individual countries of the responding project partners is given in the Appendix II.

Part C

Part C refers to 18 specific geological and geographic conditions potentially as limiting SGES as both CLS and OLS because of the administrative or legal regulation. The posed question is: *Is SGES allowed under the specific conditions listed below?* The possible replies are: *yes*, *no*, *case to case decision* and *decision up to regional regulations*. In addition, a special place for comments to each question is provided. The exact list of the considered conditions is provided in Tab. 3 and Appendix III.

Tab. 3 List of closed questions of the partner questionnaire, part C

#	Question and conditions*
	Is SGES allowed under the specific conditions listed below?
C.1	Artesian and confined aquifers
C.2	Shallow unconfined aquifers into which reinjection can be problematic
C.3	Perched aquifers
C.4	Multi-layered aquifer systems
C.5	Mineral and medicinal water resources
C.6	Thermal water resources
C.7	Gas emanations, natural and /or anthropogenic
C.8	Mining areas, including such aspects as: cone of depression in open cast mining, dewatering, land surface movement due to mining, etc.
C.9	Contaminated soils and groundwater
C.10	Evaporates, e.g. halite, gypsum, anhydrite
C.11	Swellable rocks, e.g. anhydrite, clays
C.12	Karstic areas
C.13	Water protection areas
C.14	Nature protection areas
C.15	Flood and erosion areas
C.16	Landslide and mass movement areas
C.17	Costal zones
C.18	Other, please specify if applicable

*partner questionnaire run in 2019-2020

Part D

Part D comprises a series of questions referring to the selected regulation elements on SGES operation in the following manner:

- both OLS and CLS together: 4 questions;
- OLS: 13 questions;
- CLS: 16 questions.

The possible replies are: *yes*, *no*, *case to case decision* and *decision up to regional regulations*. In addition, a special place for comments to each question is provided. The list of the regulation elements of the part D is given in Tab. 4 as well as in the Appendix IV.

Tab. 4 List of closed questions of the partner questionnaire, part D

#	Questions / regulation elements*
	OLS and CLS
D.1	Is the drilling below the groundwater table allowed?
D.2	Is the certification for the designers, planners and installers mandatory?
D.3	Is the certification for drilling companies mandatory?
D.4	Are the numerical simulations/ models required?
	OLS
D.5	Is the minimum distance (m) to the neighboring ground plot defined?

#	Questions / regulation elements*
D.6	Is the minimum distance (m) to the neighboring buildings defined?
D.7	Is the minimum distance (m) to the neighboring groundwater wells defined?
D.8	Is the minimum distance (m) between the wells defined?
D.9	Is the minimum distance (m) between the pumping and reinjection wells defined?
D.10	Is the minimum distance (m) to the neighboring closed loop systems defined?
D.11	Is the reinjection of used groundwater allowed?
D.12	Is the maximum allowed temperature difference (°C, K) between extracted and reinjected water defined?
D.13	Is the absolute allowed temperature range (°C, K) of the reinjected water defined?
D.14	Is the allowed temperature change (°C, K) defined?
D.15	Is the groundwater table drawdown (m) defined?
D.16	Are the groundwater investigations (dynamics, hydrochemistry, etc.) mandatory?
D.17	Is the pumping test mandatory?
	CLS
D.18	Is the minimum distance (m) to the neighboring ground plot defined?
D.19	Is the minimum distance (m) to the neighboring buildings defined?
D.20	Is the minimum distance (m) to the neighboring groundwater wells defined?
D.21	Is the minimum distance (m, % of well depth) between the borehole heat exchangers defined?
D.22	Is the target value for the average initial and input temperature (°C, K) of the heat carrier fluid defined?
D.23	Are there any specific regulations on the heat carrier fluid type?
D.24	Are there any specific regulations on the refrigerant type?
D.25	Are there any regulations for the grouting of the borehole heat exchanger?
D.26	Is the flow test of the closed-loop and refrigerant tubing mandatory?
D.27	Is the tightness test of the closed-loop and refrigerant tubing mandatory?
D.28	Is the borehole drilling report mandatory?
D.29	Is the sampling of the cuttings mandatory?
D.30	Is the sampling of the drilling core mandatory?
D.31	Is the thermal response test (TRT) mandatory?
D.32	Is the exact measurement of the borehole depth mandatory?
D.33	Are the groundwater investigations (dynamics, hydrochemistry, etc.) mandatory?

*partner questionnaire run in 2019-2020

Part E

Part E contains 34 questions aiming at gathering new information and providing more precision to the selected thematic areas in the following manner:

- comprehensive register of SGE installations and/or systems: 5 questions;
- monitoring of SGE installations and/or systems: 18 questions;
- environmental monitoring of SGE installations and/or systems: 11 questions.

The possible replies are: *yes*, *no*, *case to case decision* and *decision up to regional regulations*. In addition, a special place for comments to each question is provided. The exact list of questions of part E is given in Tab. 5 and in the Appendix V.

Tab. 5 List of closed questions of the partner questionnaire, part E.1 – E.3

#	Questions*
E.1	**Comprehensive register of SGE installations / systems**
E.1.1	Do you have in your country a register of SGE installations?
E.1.2	If yes, is it comprehensive and regularly updated?
E.1.3	If yes, is your GSO involved in running the register?
E.1.4	If yes, is the register publically available?
E.1.5	If no, is the lack of the register a barrier for development of SGE market?
E.2	**Monitoring of SGE installations / systems**
E.2.1	Is monitoring of SGE installations (system efficiency and/or environmental) compulsory in your country?
E.2.2	If yes, do the authorities enforce monitoring?
E.2.3	If yes, is monitoring applied to all installations independently of the installed capacity or only to large capacity installations? If yes, what is the minimum capacity for obligatory monitoring (write the threshold value in comments)?
E.2.4	If yes, do the authorities run a general digital database in which the monitoring data of the individual installations is stored?
E.2.5	If yes, are the monitoring results of the public buildings publically available?
E.2.6	If yes, is your GSO involved in monitoring of SGE installations?
E.2.7	If yes, are there any recommendations on monitoring of efficiency of SGE installations available?
	If yes, which parameters are monitored:
E.2.8	Heating/cooling installed capacity
E.2.9	Operating hours
E.2.10	Electricity consumption
E.2.11	Water extraction volume
E.2.12	Water injection volume
E.2.13	Temperature of extracted water
E.2.14	Temperature of injected water
E.2.15	Ground temperature
E.2.16	Heating/cooling medium temperature
E.2.17	Thermal energy production
E.2.18	Other
E.3	**Environmental monitoring of SGE installations / systems**
E.3.1	Are there any recommendations on environmental monitoring related to SGE installations (during all phases, e.g. construction, operation)?
E.3.2	If yes, is environmental monitoring required in relation to SGE construction phase (e.g. drilling, testing, etc.)?
E.3.3	If yes, is your GSO involved in environmental monitoring of SGE installations?
E.3.4	If yes, is installation of monitoring wells and/or piezometers for environmental monitoring of SGE installations required?
	If yes, which parameters are monitored:
E.3.5	Groundwater head
E.3.6	Groundwater temperature
E.3.7	Physiochemical parameters of groundwater, e.g. EC, TDS, pH, Eh, O2 conc., etc.
E.3.8	Chemical composition of groundwater
E.3.9	Contamination of groundwater, rocks and soils
E.3.10	Microbiota in groundwater, rocks and soils
E.3.11	Other

*partner questionnaire run in June 2020

Eventually, the feedback to the partner questionnaire was collected from 14 project partners. All respondents provided their replies to the parts A, C, D and E, however due to lack of binding regulations or their complex character preparation of the part B and the flowcharts illustrating licensing procedures was possible or partly possible for eleven partners. Tab. 6 provides the summary of feedback received from the project partners to the questionnaires.

Tab. 6 Feedback received from the project partners in response to the questionnaire, parts A-E

#	Partner acronym	Country/ region	Country code	Part A*	Part B*	Part C&D*	Part E**
P01	GBA	Austria	AT	Yes	Yes	Yes	Yes
P02	UKRI	United Kingdom	UK	Yes	Yes	Yes	Yes
P03	ICGC	Spain/Catalonia	ES-CT	No	No	No	No
P04	HGI-CGS	Croatia	HR	Yes	Yes	Yes	Yes
P05	CGS	Czech Republic	CZ	Yes	Yes	Yes	Yes
P06	BRGM	France	FR	Yes	Yes	Yes	Yes
P07	GSI	Ireland	IE	Yes	Yes	Yes	Yes
P08	RBINS-GSB	Belgium	BE	Yes	No	Yes	Yes
P09	GeoZS	Slovenia	SI	Yes	Yes	Yes	Yes
P10	IGME	Spain	ES	Yes	No	Yes	Yes
P11	SGU	Sweden	SE	Yes	Yes	Yes	Yes
P12	TNO	The Netherlands	NL	Yes	Yes	Yes	Yes
P13	PIG-PIB	Poland	PL	Yes	Yes	Yes	Yes
P14	SGIDS	Slovakia	SK	Yes	Yes	Yes	Yes
P15	GEOINFORM	Ukraine	UE	No	No	No	No
P16	GEUS	Denmark	DK	Yes	No	Yes	Yes
TOTAL Yes:				**14**	**11**	**14**	**14**
TOTAL No:				**2**	**5**	**2**	**2**

Yes – feedback provided

No – no feedback provided

*partner questionnaire run in June 2020

**partner questionnaire run in June 2020

5 ENERGY AND CLIMATE MANAGEMENT ON EU LEVEL

5.1 Development of policies and strategies

The first EU strategy addressing comprehensively energy and climate goals was the **EU 2020 Energy Strategy** (COM(2010) 639 final) established in 2010. This aimed at reduction of the greenhouse gas emissions by at least 20%, increase of the share of renewable energy to at least 20% of consumption, and achievement of energy savings of 20% or more. Through the attainment of the targets, the EU would help to combat climate change and air pollution, decrease its dependence on imported fossil fuels, and keep energy affordable for consumers and businesses. In order to meet these targets, the 2020 Energy Strategy sets out five priorities, among them the **Strategic Energy Technology Plan** (SET Plan) which aims to accelerate the development and deployment of low-carbon technologies. It also seeks to improve new technologies and bring down costs by coordinating national research efforts and helping to finance projects. The SET Plan promotes research and innovation efforts across Europe by supporting the most impactful technologies in the EU's transformation to a low-carbon energy system. It promotes cooperation across the European countries, companies, research institutions, etc. In order to support the implementation of the SET Plan the **European Technology and Innovation Platform** on **Renewable Heating and Cooling** (ETIP RH&C) has been created by bringing together EU countries, industry, and researchers in key areas. The **European Geothermal Energy Council** (EGEC) is one of the ETIP RH&C members.

The EU also set a long-term goal of reducing greenhouse gas emissions by 80-95%, compared to 1990 levels, by 2050. **The Energy Roadmap 2050** (COM(2011) 885 final), also called **2050 Energy Strategy,** explores the transition of the energy system in ways that would be compatible with this greenhouse gas reductions target, while also increasing competitiveness and security of supply. The European Commission's 2011 Energy Roadmap set out four main routes to a more sustainable, competitive and secure energy system in 2050: energy efficiency, renewable energy (including SGE), nuclear energy, as well as carbon capture and storage.

In 2014, the European Council agreed on a new policy, i.e. **2030 Framework for Climate and Energy** (COM(2014) 15 final, COM(2014) 520 final), also called **2030 Energy Strategy**, including EU-wide targets and policy objectives for the period between 2020 and 2030. These aim to help the EU to achieve a more competitive, secure and sustainable energy system and to meet its long-term 2050 greenhouse gas reduction target. The figures for renewables and energy efficiency have subsequently been increased in the context of the **Clean Energy for all Europeans package** (COM(2016) 860 final). The 2030 framework aims to help the EU to address following issues:

- taking the next step towards the goal of reducing greenhouse gas emissions by 80 - 95% below 1990 level by 2050;
- high energy prices and the EU economy's vulnerability to future price rises, especially for oil and gas;
- the EU's dependence on energy imports, often from politically unstable areas;
- the need to replace and upgrade energy infrastructure and provide a stable regulatory framework for potential investors;
- agree on a greenhouse gas reduction target for 2030.

The 2030 framework proposes the new targets and measures to make the EU's economy and energy system more competitive, secure and sustainable. It includes the targets for reducing greenhouse gas emission and increasing use of renewable energies, and proposes a new governance system and performance indicators. In particular, it proposes the following actions:

- a commitment to continue reducing greenhouse gas emissions, setting a reduction target of 40% by 2030 relative to 1990 levels;
- a renewable energy target of at least 27% of energy consumption, with flexibility for member states to set the national targets;
- improved energy efficiency through the possible amendments to the energy efficiency directive;
- reform of the EU emissions trading scheme to include a market stability reserve;
- key indicators – on energy prices, supply diversification, interconnections between member states and technological developments - to measure progress towards a more competitive, secure and sustainable energy system;
- a new governance framework for reporting by member states, based on national plans coordinated and assessed at EU level.

The **Energy Union** (COM(2015) 80 final) helps to provide secure, affordable and clean energy for EU citizens and businesses. The strategy builds further on the 2030 Framework for Climate and Energy and the European Energy Security Strategy. It is made up of five closely related and mutually reinforcing dimensions including innovation and competitiveness, energy efficiency, decarbonising the economy, research, innovation and competitiveness, all of them being addressed by MUSE as well. The EC's Clean Energy for All Europeans package (COM(2016) 860 final), which was published in 2016, includes a proposal for a Regulation on the Governance of the Energy Union.

Except for the policies on energy and related legal framework, the EU also establishes law on air quality and standards. Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants aims at limiting emissions of acidifying and eutrophying pollutants and ozone precursors in order to improve the protection in the community of the environment and human health against risks of adverse effects from acidification, soil eutrophication and ground-level ozone. Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, among others, defines the limits for the new air quality objectives for PM2.5 including the limit value and exposure related objectives, i.e. exposure concentration obligation and exposure reduction target.

Mitigation of global warming is the main goal of the **Paris Agreement** (2015, COM(2016) 110 final) which sets out a global framework to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C. It has been signed by 194 countries as well as the EU. In order to reach the goal of the Paris agreement, countries are required to set goals for their climate efforts every five years, increasing their level of ambition over time. The agreement also aims to strengthen countries' ability to deal with the impacts of climate change and support them in their efforts. The studies of the **International Renewable Energy Agency** (IRENA) (IRENA 2019) highlights the deployable, cost-effective options for countries to fulfil climate commitments and limit the rise of global temperatures.

The newest, agreed in 2020, EU policy on climate and energy is the **European Green Deal** (COM(2019) 640 final, Bouzarovski et al. 2020) which assumes that the EU will gradually become climate and carbon neutral by 2050. In order to achieve that goal, a roadmap was proposed covering all sectors of economy, including:

- investing in environmentally-friendly technologies;
- supporting industry to innovate;
- rolling out cleaner, cheaper and healthier forms of private and public transport;
- **decarbonising the energy sector**;
- **ensuring buildings are more energy efficient;**
- working with international partners to improve global environmental standards.

The EU plans to provide financial support and technical assistance to help people, businesses and regions that are most affected by the move towards the green economy. This is called the **Just Transition Mechanism** (COM(2019) 640 final, Bouzarovski et al.) which will help to mobilise at least 100 billion (1 trillion) Euro over the period of 2021 - 2027 in the most affected regions. What is important, the mechanism will support the transition of the coal mining areas in the EU into a future decarbonised economy and society. The financial sources will be allocated according to specific criteria and priority will be given to the regions with a large number of employees in coal, peat mining or shale oil and gas industry. The European Green Deal emphasises the need for decarbonisation of the EU societies. The idea is to a large extent supported by the promotion of SGE as one of the cleanest energy type which is the major objective of the MUSE project.

5.2 Key documents

In support of the EU 2020 Energy Strategy, the following EU Directives, namely, the **Renewable Energy Directive** 2009/28/EC and **Energy Efficiency Directive** 2012/27/EU, were put into force. The Renewable Energy Directive 2009/28/EC specifies national renewable energy targets for each EU member state, taking into accounts it's starting point and overall potential for renewables. The EU member states set out how they plan to meet these targets and the general course of their renewable energy policy in **National Renewable Energy Action Plans** (NREAPs) including use of SGE for heating and cooling. Progress towards the national targets is measured every two years when the EU countries publish the national renewable energy progress reports. The 2012/27/EU Directive establishes a set of binding measures to help the EU to reach its 20% energy efficiency target by 2020. Under this directive, all EU countries are required to use energy more efficiently at all stages of the energy chain, from production to final consumption. In 2016 the EC proposed an update to the Energy Efficiency Directive, including a new 30% energy efficiency target for 2030, and measures to update the Directive to make sure the new target is met. To help officials in EU countries implement the Energy Efficiency Directive, the European Commission publishes guidance notes. In December 2018, the **Revised Renewable Energy Directive** 2018/2001/EU (RED II) entered into force. The directive was a part of the *Clean*

energy for all Europeans package and aimed at keeping the EU a global leader in renewables and helping it to meet its emissions reduction commitments under the Paris Agreement (2015, COM(2016) 110 final). The RED II Directive established a new binding renewable energy target for the EU for 2030 of at least 32%, with possibility for upwards revision by 2023. The EU legal framework on energy and climate, including RES and RED II directives, explicitly recognizes the resource of geothermal energy and their significant role in energy transition and decarbonisation of economy.

Another significant act of EU law exerting significant influence on SGE, especially on open systems, is the **Water Framework Directive** (WFD) 2000/60/EC. This commits the EU member states to achieve good qualitative and quantitative status of all water bodies, including groundwaters and marine waters, by 2015. It is a framework in the sense that it prescribes steps to reach the common goal rather than adopting the more traditional limit value approach. The directive's aim for a good status for all water bodies will not be achieved, with 47% of EU water bodies covered by the directive failing to achieve the aim. One important aspect of the WFD is the introduction of River Basin Districts and, based on them, water management system. The **Groundwater Directive** 2006/118/EC, also called GWD Directive, refers to the protection of groundwater against pollution and deterioration and as such addresses also OLS and, to a large extent, CLS too.

6 RELEVANT EU PROJECTS

The EU enhances achievement of the objectives of its energy and climate strategies through support of the diverse types of projects, such as scientific, structural and investment ones. The most critical projects referring to RES and SGES, the results of which MUSE is building upon, are discussed below. Their major outcomes were identified, examined and described below. The summary of the selected EU projects with respect to their objectives and results relevant to MUSE is given in Tab. 7.

6.1 GeoTrainet

Project title: *Geo-Education for a sustainable geothermal heating and cooling market*

Duration period: 2008-2011

Financing programme: IEE

Websites: https://ec.europa.eu/energy/intelligent/projects/en/projects/geotrainet; http://geotrainet.eu/ (GeoTrainet AISBL – the international non-profit organisation)

The project aimed at developing a Europe-wide educational programme as an important step towards the certification of SGE installations. It focused on two major target groups, namely, designers (those who carry out the feasibility and design studies, including geological and hydrogeological settings), planners and drillers (those who drill the boreholes and install the BHEs). The major objectives of GeoTrainet were as follows:

- to analyse the technologies applied in SGE in different EU countries;
- to analyse the legislation and policy with respect to SGE on EU and national levels;
- to provide proper education of the professional personnel responsible for designing and drilling of the SGES across Europe;
- to create an international platform of experts on SGE Heating and Cooling to provide the knowledge required for the education on this area;
- to create the curricula and training tools and didactic materials for the SGES designers and drillers;
- to publish two training manuals available online:
  - *GeoTrainet Training Manual for Drillers of Shallow Geothermal Systems* (Sanner et al. (eds.) 2011);
  - *GeoTrainet Training Manual for Designers of Shallow Geothermal Systems* (McCorry and Jones (eds.) 2011);
- to run the training courses for the designers and drillers of the SGE based on the unified curriculum;
- to improve an access to geological data needed for the design of SGES;
- to elaborate guidelines for facilitation of the acquisition of geological data and evaluation of the SGES;
- to suggest the common standards and codes to create a unified European market;
- to develop a European structure for training in SGE;
- to develop a proposal for a European certification framework.

Two manuals published as the results of the project, i.e. *GeoTrainet Training Manual for Drillers of Shallow Geothermal Systems* (McCorry, Jones (eds.) 2011) and *GeoTrainet Training Manual for Designers of Shallow Geothermal Systems* (Sanner et al. (eds.) 2011) play a crucial role for the professionals and general stakeholders interested in SGE, both CLS and OLS until present. Within the framework of the project the training courses for the interested stakeholders were organized in selected European cities. The training materials are available through the website of GeoTrainet AISBL, the non-profit association established after the accomplishment of the project. Except for the extensive technical information, the manual for the designers includes some concise information on the EU regulatory framework and legislation which due to period of implementation of the project requires some update.

6.2 STEP UP

Project title: *Strategies Towards Energy Performance and Urban Planning*

Financing programme: FP7

Duration period: 2008-2011

Websites: https://www.stepupsmartcities.eu; https://cordis.europa.eu/project/id/314679

The projects aimed at enhancing Strategic Energy Action Plans (SEAPs) in four partner cities, i.e. Glasgow, Ghent, Riga and Gothenburg, to tackle energy targets, such as, energy efficiency, energy use reduction, growth of renewable energy and carbon emissions reduction. A created model for energy planning should be further disseminated across Europe. Under the EU Covenant of Mayors, signatory cities committed to meeting or exceeding the EU's 20% $C0_2$ reduction target. Through SEAPs the signatory cities outlined the activities, measures and time frames showing how they would reach the EU's CO_2 reduction target by 2020. STEP UP also intended to:

- create a model for energy planning that will deliver faster and greater impact, contributing to meeting Europe's 2020 energy and climate change targets;
- support delivery of policy objectives such as improving security of energy supplies, achieving urban regeneration, economic growth, tackling fuel poverty.

Existing SEAPs for the project partner cities were improved based on a nine-step programme which provided a framework guiding the user towards the targeted and constructive process of designing a SEAP or improving an existing one. The individual steps are summarized in the guidebook *Developing enhanced Sustainable Energy Action Plans - A STEP UP guide for cities*. Each step is accompanied by a brief *Lessons learned* section and relevant spreadsheet templates. The more detailed guidebooks exist for a number of steps. A number of the project management tools and visualization aids (e.g. PEST analysis, SWOT analysis, scenario analysis, etc.) are introduced where appropriate. The guidebook was created to facilitate the compilation of entire SEAPs and aimed specifically at urban areas. The report *Developing Sustainable Energy Projects* asserted the benefits of integrated measures over stand-alone

actions and offered good practice examples. These acted as starting points for the elaboration of integrated measures in those pilot areas which collaborated closely with the urban planners.

6.3 ReGeoCities

Project title: *Regulations of Geothermal HP systems at local and regional level in Europe*

Financing programme: IEE

Duration period: 2012-2015

Website: https://ec.europa.eu/energy/intelligent/projects/en/projects/regeocities#results

The project focused on the achievement of NREAP geothermal targets 2020 marked by the countries with ambitious objectives regarding the CLS and OLS by means of the removal and clarification of the non-technical administrative and/or regulatory barriers at the local and regional level. It examined and promoted good practices and an intelligent regulatory framework, supporting the cities to fulfil their SEAPs and the 2020 climate and energy goals. The project developed *The Heat Under Your Feet* campaign in order to promote greater awareness about the GSHP industry in Europe (EGEC 2020). The project also engaged and collaborated with regional and local administrations. A complete training program targeting the staff members in regional and local public authorities was developed and implemented to provide this target group with the skills and tools needed to facilitate and assist during the regulative process of SGES. The major objectives of ReGeoCities were as follows:

- to overcome the barriers related to regulation of SGE resources and administrative procedures;
- to transfer the best practices from mature to juvenile regions;
- to document a common pre-normative framework with recommendations for implementation;
- to engage local administration to implement project results;
- to develop a training program focused on the target groups including the administrative personnel from the cities and regions;
- to achieve the smart-cities concept within SGES.

ReGeoCities also provided an analysis of the current SGE market in Europe, i.e. the deliverable D1.3 *Analysis of Market for Shallow Geothermal Energy* (Sanner, Angelino 2015). The legal definitions of several terms used in the context of SGE and binding in EU regulations, i.e. the deliverable D2.2 *General report of the current situation of the regulative framework for the SGE systems* (Jaudin et al. eds. 2013) were provided as well as a detailed overview of the EU legal documents referring to SGE (Dumas 2015). The scope of ReGeoCities project covered also the selected issues on SGE application in urban environments by the deliverable D3.3 *Main aspects for integration of SGE systems in Cities and Buildings* and the support tools to boost the development of GSHP (Benson et al. 2014), including best practices in financial incentives, insurance schemes, management of resources and instructions for documentation in the deliverable D.3.1 *Best practice analysis report* (Pasquali 2013). As a result, a set of common regulatory framework guidelines, aimed at facilitating local authorities in Europe in implementing regulatory and permitting procedures for SGE systems was presented, including reviews and summary of information on EU energy regulatory framework and policies included in the

deliverable D3.4 *Recommendation guidelines for a common European regulatory framework*. In addition, the complex processes of policy making at EU level combined with permitting, construction, monitoring and information was illustrated with a flowchart (Pasquali, O'Neill 2015).

ReGeoCities dealt with the processes of policy making at EU level combined with permitting, construction, monitoring and information which were illustrated with a flowchart in the deliverable D3.4 and its Annex II comprising a flowchart illustrating the processes of policy making at EU level combined with permitting, construction, monitoring and information.

The project provided important information on national level, for example deliverable D.T2.4.2 *Catalogue of reviewed quality standards, current policies and regulations*. The deliverable D5.5 *Report Promoting the inclusion of shallow geothermal energy in SEAPS* focuses on an important aspect of the H&C systems with GSHP – the life cycle costing (LCC) analyses due to its positive influence on the inclusion in SEAPs. Another major achievement of the ReGeoCities is the database for public authorities developed as an Excel spreadsheet. Application of the database is described in the deliverable 3.2 *Database Handbook* (Beek, Godschalk 2013).

6.4 progRESsHEAT

Project title: *Supporting the progress of renewable energies for heating and cooling in the EU on a local level*

Financing programme: Horizon 2020

Duration period: 2015-2017

Website: http://www.progressheat.eu/

The project aimed at assisting the political leaders in developing policies and strategies for efficient deployment of RES in heating and cooling (H&C) networks (Holländer et al. 2016). It was intended to support the market uptake of existing and emerging renewable electricity and H&C technologies. More specifically, the project helped the policy makers to develop the integrated, effective and efficient policy strategies aimed at achieving a fast and strong penetration of RES and efficient H&C systems. It covered the analysis of cross-sectoral effects between the diverse RES and energy efficiency measures in industrial heat and cold, waste heat, spatial heating and cooling and district heating. The overall goals of progRESsHEAT were as follows:

- to support the implementation of national H&C plans which were to be released by the EU member states by the end of 2015;
- to assist the national policy makers in implementing suitable policies with a model-based quantitative impact assessment of local, regional and national policies up to 2050.

The project analysed the barriers, issued recommendations for the promotion of geothermal energy and elaborated energy strategies for each of its 6 pilot areas. The project activities referred to energy policy in general, however, some points were associated with geothermal energy. The reports reviewed the relevant EU regulations, EU targets and case studies. The report *Heating & cooling: Policy*

frameworks in six European cities, their regions and countries contributed with the description of selected policies in selected cities.

6.5 GRETA

Project title: *Near-surface Geothermal Resources in the Territory of the Alpine Space*

Financing programme: Interreg Alpine Space Programme 2014-2020

Duration period: 2015-2018

Website: https://www.alpine-space.eu/projects/greta/en/home

The project aimed at improving energy efficiency and sustainable production of SGE in the Alpine region. The project elaborated geothermal potential maps as decision support tools for the integration of SGE into policy instruments, e.g. energy plans and strategies, and as such could be used for spatial planning of SGES by public and private stakeholders. The strategies for the inclusion of SGE in policy instruments were also formulated, contributing to increase of SGE utilization. The project brought new opportunities to SGE application and fostered the efficient implementation and operation of near-surface geothermal systems in the Alpine region. The objectives of GRETA were as follows:

- **Increasing knowledge on the spatial distribution of SGE potential in the area:**

  The geothermal potential maps as a decision support tool for the integration of SGE into policy instruments, such as energy plans and strategies, and for the spatial planning of geothermal installations by public and private stakeholders (GRETA 2018a).

- **Exchanging knowledge and best-practices on a transnational base:**

  Publications based on field observations and case studies considering technical, economic, environmental and social issues in order to give a general point of view among the situation and about SGE applications progresses in the Alpine Space.

- **Planning tools to develop a database open to all:**

  Guidelines reviewing and summarizing regulations, authorization procedures and operational criteria of SGE utilization provided for the implementation of SGE into policy instruments, such as energy plans and strategies, thus contributing to a growth of SGE utilization (GRETA, 2018b).

GRETA aimed to crosscheck the existing country-specific regulations and reviewed best administrative practices for SGE systems in the Alpine region. The deliverable T2.1.1 *Overview and analysis of regulation criteria and guidelines* provided the guidelines for SGE use (Greta 2018c). In coordination with user interaction, existing national and regional regulations were analysed with focus on the barriers and drivers affecting regulation of SGE plants in the Alpine region. GRETA dealt with relevant technical and operational criteria for SGES under the typical conditions of the Alpine environment (GRETA 2018d). Best practice examples from existing plants were analysed in order to derive a review of the most crucial and operational criteria for diverse SGES with a transnational validity across the region. In effect, a dedicated methodology for the identification of the stakeholders' needs in the field

of near surface geothermal energy (NSGE), as SGE is referred to by the GRETA project, was developed (GRETA, 2017).

6.6 GeoPLASMA-CE

Project title: *Shallow Geothermal Energy Planning, Assessment and Mapping Strategies in Central Europe*

Financing programme: Interreg Central Europe Programme 2014-2020

Duration period: 2016-2019

Website: www.interreg-central.eu/Content.Node/GeoPLASMA-CE.html

The project aimed at fostering the share of SGE use in H&C strategies in Central Europe. GeoPLASMA-CE created a web-based interface between geoscientific experts, public and private stakeholders to make the existing know-how about resources and risks associated to SGE accessible for territorial energy planning and management strategies in Central Europe (Goetzl 2020). The project dealt with different aspects of SGE use for H&C in both urban and non-urban regions. In cooperation with the selected GSO, universities, non-profit organizations, administrative bodies and private expert companies, the new management strategies for a reasonable and sustainable use of SGE were explored in 6 different pilot areas located in Germany, Austria, Poland, Czech Republic, Slovakia and Slovenia (Kłonowski et al. 2018). The ambition of GeoPLASMA-CE was to analyse the EU and national legal requirements and SGE policies which is presented in deliverable D.T2.4.1 *Summary of national legal requirements, current policies and regulations of shallow geothermal use* (Ruprecht et al. 2017) as well as the quality standards and regulations as discussed in deliverable D.T2.4.1 *Catalogue of reviewed quality standards, current policies and regulations*) (Ruprecht et al. 2018). The deliverable D.T4.1.2 *Joint report on the user demands and barriers for the implementation of shallow geothermal methods in energy planning strategies*) (Goetzl, Heiermann, Kłonowski 2018) identified the barriers for SGE development, while the deliverable D.T4.4.1 *Strategy report for future energy planning and management concepts to foster the use of shallow geothermal* (Goetzl et al. 2019) proposed solutions and recommendations to foster the SGE use.

The project activities covered also the assessment of existing and emerging data, which determine potentials and risks of SGE use. The project produced a comprehensive web portal for the use of SGES for H&C which comprised a web based decision support and information tool based on geoscientific 3D models applied in six pilot areas. The project elaborated six strategies for the use of SGE written in cooperation with the local stakeholders and intended to feed into the local and regional policy circles (Goetzl et al. 2018). In addition, the project developed a joint strategy for fostering the use of SGE in Central Europe (Ruprecht et al. 2019) and prepared the appropriate handbook for its implementation, i.e. *Handbook for a successful implementation of Shallow Geothermal Energy* (Heiermann et al. (eds.) 2019).

6.7 HRE4

Project title: *Heat Roadmap Europe: Building the knowledge, skills, and capacity required to enable new policies and encourage new investments in the heating and cooling sector*

Financing programme: Horizon 2020

Duration period: 2016-2019

Website: https://heatroadmap.eu/; https://www.euroheat.org/our-projects/heat-roadmap-europe-4

The goal of HRE4 was to develop the low-carbon heating and cooling strategies, called *Heat Roadmaps*, by quantifying and implementing changes at the national level for 14 EU member states, which all together accounted for approximately 85 - 90% of total heating and cooling in Europe. The project builds on three previous HRE studies, all of which have already influenced the high-level policymakers at EU and national level in Europe. The project prepared the ground for new investments by creating more certainty in relation to the changes that are required for transition to decarbonized economy. The overall goal of the project was to create the scientific evidence required to support the decarbonisation of the H&C market in Europe and redesign this sector, by combining the knowledge of local waste heat conditions, potential savings and energy system analysis. HRE4 aimed specifically to:

- build evidence that supports decarbonisation of the heating and cooling sector in Europe;
- redesign the energy sector by combining the knowledge of local waste heat conditions and potential savings with an energy system analysis;
- promote transparency in energy research by sharing data, results, models and methodologies on open platforms as well as be open for new partnerships.

The major project outputs and results were:

- quantification of the heating and cooling demand in Europe including present scenario and forecast of their future development;
- baseline scenario of the total energy system up to 2050;
- baseline scenario of H&C demand in buildings and industry in until 2050;
- pan-European thermal atlas of H&C demand in Europe;
- map of the heat synergy regions and the cost to expand district H&C;
- quantification of the excess heat volumes available from power plants, waste incineration, and industry in Europe, all of which can be utilised on district heating networks;
- quantification of RES available for district heating networks in Europe, including large-scale solar thermal, direct geothermal, and heat pumps;
- comparison at European level between the cost of heat savings and sustainable heat supply;
- models that simulated the impact of district H&C, including their impact on the electricity and industrial sectors;
- study to demonstrate how a simultaneous expansion of heat savings, district heating, and heat pumps will result in the cheapest low-carbon heat sector for Europe;
- roadmaps, including *Main Report* and *Heat Roadmaps by Country*;

- guidelines for lead users and business strategies;
- guidelines for the energy system transition;
- business strategies and business cases to encourage market uptake.

6.8 DeCarb

Project title: *Supporting the Clean Energy Transition of Coal-Intensive EU Regions*

Financing programme: Interreg Europe Programme 2014-2020

Duration period: 2018-2023

Website: https://www.interregeurope.eu/decarb/

The low-carbon energy shift of EU economies will have a profound economic and social impact on the regions extensively involved in coal value chains. The overall goal of the ongoing DeCarb project is to exchange experiences and transfer knowledge on transition from the carbon-intensive era towards the clean decarbonised energy future. It supports the coal-intensive regions to ensure sustainable development, economic and societal stability, and a substantial role in the 2030 energy mix. DeCarb supports the public authorities of the regions to initiate efforts, join forces and exchange experiences to:

- identify growth strategies to mitigate the impact of decarbonisation;
- make the most of EU funds and financing tools;
- promote public dialogue on conflicting interests.

The planned main outputs of the DeCarb project are:

- action plans to improve the addressed policy instruments, benefiting managing authorities and beneficiaries;
- interregional workshops, site visits and an EU-wide policy learning event to promote capacity building among the partners and stakeholders;
- policy briefs to transfer lessons learnt to EU public authorities;
- training toolkit on the development of energy mix scenarios for regions undergoing decarbonisation;
- joint thematic studies and analyses reports on territorial needs and decarbonisation pathways.

Tab. 7 Summary of the relevant EU projects

Acronym **Duration** **Financing programme**	**Key objectives**	**Results relevant to MUSE**
GeoTrainet 2008-2011 IEE	• Analysis of SGE technologies and EU legislation, policies and strategies • Preparation of guidelines for facilitation of the acquisition of geological data and evaluation of the SGE installation; • Development of proposal for a European certification framework	• 2 training manuals, i.e. for drillers and designers of SGE installations • Training courses for the stakeholders organized in different countries
STEP UP 2012-2015 FP7	• Creation of energy planning model for faster impact and contribution to meeting EU's 2020 energy and climate goals; • Supporting policy objectives and improving security of energy supplies, achieving urban regeneration	• Guidebook *Developing enhanced Sustainable Energy Action Plans - A STEP UP guide for cities* • Report *Developing Sustainable Energy Projects* • Integrated model for delivering ambitious SEAPs in cities • Training programmes for professionals and a course on sustainable city planning and implementation
ReGeoCities 2012-2015 IEE	• Overcoming the barriers related to regulation of GER and administrative procedures; • Transferring best practices from mature to juvenile regions • Developing training program focused on administrative personnel from the cities and regions • Achieving the smart-cities concept within SGE systems	• *Developing geothermal heat pumps in smart cities and communities* • *Analysis of market for shallow geothermal energy* • *General report of the current situation of the regulative framework for the SGE systems* • *Main aspects for integration of SGE systems in Cities and Buildings* • *Best practice analysis report* • *Recommendation guidelines for a common European regulatory framework* • Campaign *The Heat Under Your Feet*
progRESsHEAT 2015-2017 Horizon 2020	• Supporting implementation of national H&C plans • Assisting policy makers in implementation of policies with a model-based impact assessment of local, regional and national policies up to 2050	• *Policy frameworks in six European cities, their regions and countries* contributing with the description of selected policies, as exemplary ones, in the selected cities

Acronym Duration Financing programme	Key objectives	Results relevant to MUSE
GRETA 2015-2018 Interreg Alpine Space Programme	• Increasing knowledge on spatial distribution of SGE potential • Exchanging knowledge and best practices on a transnational base	• *Overview and analysis of regulation criteria and guidelines* • *A methodology for the identification of the Stakeholders' needs in the field of NSGE* • Examples of best practices
GeoPLASMA-CE 2016-2019 Interreg Central Europe Programme	• Fostering the share of SGE use in H&C strategies in Central Europe • Transferring knowledge from scientific experts to public authorities and related entities	• Web portal with web GIS resources and conflict maps and knowledge platform for SGE • *Catalogue of success criteria for a sustainable management of SGE use* • *Summary report on existing energy planning strategies in the EU considering the use of shallow geothermal energy* • *Summary of national legal requirements, current policies and regulations of shallow geothermal use* • *Catalogue of reviewed quality standards, current policies and regulations* • *Joint report on the user demands and barriers for the implementation of shallow geothermal methods in energy planning strategies* • *Strategy report for future energy planning and management concepts to foster the use of shallow geothermal*
HRE4 2016-2019 Horizon 2020	• Building evidence to support decarbonisation of the H&C sector in Europe • Redesigning the energy sector by combining the knowledge of local waste heat conditions and potential savings with an energy system analysis • Promoting transparency in energy research by sharing data, results, models and methodologies on open platforms as well as be open for new partnerships	• Quantification of the H&C demand in Europe including present scenario and forecast of their future development • Baseline scenario of the total energy system up to 2050 • Baseline scenario of the H&C demand in buildings and industry until 2050 • Pan-European thermal atlas (Peta) of the H&C demand in Europe • Map of the heat synergy regions and the cost to expand district H&C • Main Report and Heat Roadmaps by Country • Guidelines for lead users and business strategies • Guidelines for the energy system transition

Acronym Duration Financing programme	Key objectives	Results relevant to MUSE
DeCarb 2018-2023 Interreg Europe Programme	• Identifying growth strategies to mitigate the impact of decarbonisation • Making the most of EU funds and financing tools • Promoting public dialogue on conflicting interests	• Action plans to improve the addressed policy instruments, benefiting managing authorities and beneficiaries • Interregional workshops, site visits and an EU-wide policy learning event to promote capacity building among the partners and stakeholders • Policy briefs to transfer lessons learnt to EU public authorities • Training toolkit on the development of energy mix scenarios for regions undergoing decarbonisation • Joint thematic studies and analyses reports on territorial needs and decarbonisation pathways

7 EXISTING STUDIES ON INTERNATIONAL LEGAL STATUS AND SGE MANAGEMENT CONCEPT

The MUSE project considers and builds upon the results of the existing studies on the legal status of SGE on EU and wider international level. Investigations of legal situation and regulations on SGE worldwide, as performed by Haehnlein, Bayer and Blum (2010), were based on analysis of replies to the customized questionnaire replied by the experts representing 46 countries showing very diverse degree of SGE use and management. It focused on the legal framework and regulation criteria referring to ecology, technology and minimum distances for both CLS and OLS types of installations. The lack of a common SGE definition, influencing diversity of legal documents and regulations, was underlined. The country overview focussed on the regulations in 39 selected countries, including analysis of the legal state and common practices. The presented survey proved heterogeneous character of international legal status of SGE regulations and provided evidence on heavily regulated SGE in European countries (Haehnlein, Bayer and Blum 2010). The regulation related to CLS and OLS varies significantly between the studied countries. One of the main purposes of environmental regulations is to control and avoid unwanted irreversible effects on the natural environment. According to the authors it would be desirable for the different regulations to converge and to establish more objective and scientifically motivated environmental, technical and economic criteria (Haehnlein, Bayer and Blum 2010). In further studies sustainability and policy on SGE use were examined (Hähnlein et al. 2013). Three types of consequences of SGE implementation, i.e. physical, chemical and biological were analyzed in the context of international policy and legislation. Intense heterogeneity of SGE regulations, lack of knowledge on worldwide SGE application as well as a need for further research were reconfirmed (Hähnlein et al. 2013).

A review of SGE legal and regulatory issues in 14 European countries was a subject to the studies by Tsagarakis et al. (2019). Investigations consisted in analyzing the responses provided by the country experts to the semi-structured survey covering specific questions regarding SGE. It is emphasized that in absence of an EU directive explicitly referring to SGE the national legal, administrative and technical issues are regulated by diverse types of laws, ministerial decisions, technical standards and guidelines. In some cases the national regulations derive even from other countries (Tsagarakis et al. 2019). The countries lacking any specific regulations were reported as well. Again lack of the SGE common definition and its different interpretations in the analyzed countries were emphasized. It was also spotted that the SGES are not sufficiently planned nor managed in studied urban areas.

A short overview of European and national energy policies with respect to possible SGE influence on reaching the RES objectives was presented in a paper by Esteban (2019). The general conclusion based on analysis of legal framework and SGE application was that although the EU legal framework encourages SGE use as an important mean for reduction of greenhouse gases through generation of hot water and air conditioning of housing, the appropriate national legislation of the individual EU member states is very diverse. It was also stated that the regulatory framework in the EU member states can be a barrier to SGES development. The lack of competences, too complex and heterogeneous procedures, delays in granting administrative approvals, costly procedures, distribution of competences were mentioned among the main obstacles for SGES progress (Esteban 2019).

A proposal on SGE management based on the implementation of a market of SGE use rights, as elaborated by Alcaraz et al. (2016), helped to cope with the spatial characteristics of the resource on a local scale. The appropriate methodology was implemented on a GIS platform. Management of SGE

in urban environment in Basel was proposed by Epting (2017). The methodology includes temperature observation system, local process- and regional management-scale flow and heat transport modelling as well as thermal management of urban subsurface resources. The studies facilitated characterization of a short-term impacts and long-term development of flow and thermal regimes in the urban areas. Patton et. all (2020) proposed establishment of an urban-area-wide geo-observatory which would provide information of subsurface conditions supporting informative decisions of policy makers, regulators, planners and developers on implementing ground source heat recovery and storage schemes. With regard to groundwater such monitoring applicable across an aquifer should allow for the characterization of the available resource and the long-term implications of its use (Farr et al. 2017; Boon et al. 2019).

The current SGE legal framework has been specifically studied under the terms of the MUSE project for Spain (García Gil, Mejías Moreno 2019). No legal documents directly differentiating SGE resources from general geothermal energy exist, however the operations are delimitated indirectly with a depth limit varying between 100 and 500 metres at a regional level. There is sound evidence that a specific legal framework should be elaborated. The topic of management of SGE resources was a subject to the MUSE deliverable D.3.2 *Guideline for integrating and managing the use of SGE in urban areas* (García-Gil, Goetzl, Kłonowski 2019; García-Gil et al. 2020). The main author refers to the adaptive management approach (Holling and Programme 1978; Walters 2001) as the most accepted and applicable path to govern the natural and renewable resources, including RES, in highly dynamic and complex environments, such as the urban areas studied by the project. Further on, in order to define the decision-making and the decision-implementation processes of management of SGE resources, it is recommended to apply the adaptive management cycle introduced in renewable resources, e.g. by Savenije and Van der Zaag (2008) for water resource management. In case of SGE resources management, two main activities or processes are proposed, i.e. the process of management planning and the process of implementation and control.

8 SUMMARY OF NATIONAL LEGAL REQUIREMENTS AND REGULATIONS

This chapter provides a general overview of national legal requirements and regulations on SGE resulting from analysis of the project partners' feedback to the questionnaire. Description of SGE related activities under the individual thematic areas considered in these studies are presented in the subchapters 8.1 – 8.11. The descriptive statistics of corresponding closed questions referring to legal regulations and licencing procedures is shown in the figures and Appendices IA and IB.

8.1 Definition of SGE

Majority of 14 project partners taking part in the survey indicated that there is no common legally binding SGE definition in their countries, although there is a common understanding of the SGE concept and of the activities pursued within the SGES. Generally, SGE is understood as geothermal energy recovered from the subsurface with the use of geothermal heat pumps, including both OLS and CLS, for, among others heating, cooling (free cooling as well as ground source based chillers) and thermal energy storage. The most often SGE concept is linked to the depth of the installations, however in some countries the suggested threshold value is only recommended and not legally regulated. On the other hand, in Poland there is a strong tendency in academia to call SGE the low-temperature or low-enthalpy geothermal energy. Such an approach has no respect to depth and is fully based on the temperature concept. Another common feature of SGE is water temperature which must be lower than 30^{O}C in Spain and 20^{O}C in Austria and Poland. In Slovakia there is no definition of SGE, though the water temperature threshold value for geothermal water is 20 °C. The situation of the individual partner countries illustrating existing legal definition of SGE is presented in Fig. 2 while the summary of replies to the respective question of the part A of the questionnaire is shown in Fig. 3.

Only two project partners, reported a legally binding SGE definition existing in their national regulations. In Croatia the definition is formulated in a legal act and is based on the depth concept, i.e. *Shallow geothermal source is the heat of Earth's crust up to 400 m depth*. On the other hand, in France the legally binding definition is based on several features, such as depth, temperature, power and volume of produced and injected water. This definition covers only a part of all SGE operations in the country, namely those called in French *geothermie de minime importance* (GMI) which corresponds to the operations that apply to the simplified declarative system of SGES.

In addition, presence of the legally binding definition was reported for Flanders in Belgium where the SGE concept comprises all geothermal systems installed within the depth interval from 0 down to 500 metres. Generally, in Belgium SGE is legally defined on the regional level and for example no definition exists in the Brussels Capital region. In the rest of the surveyed countries the existing SGE concepts rely upon the depth approach. Normally, the criteria range up to 100 - 500 metres of depth (Tab. 8).

Tab. 8 Existing SGE definitions including depth and temperature criteria

PP country	P01 AT	P02 UK	P04 HR	P05 CZ	P06 FR	P07 IE	P08 BE*	P09 SI	P10 ES	P11 SE	P12 NL	P13 PL	P14 SK	P16 DK
Legal definition	no	no	yes	no	yes	no	yes	no	no	no	no	no	no	no
Depth limit/range metres	<300	<200	<400	no	10-200	<400	<500	<300	<250	<300	<500	<100 <400	no	<250
T ^{o}C	<20 **								<30 **			<20 **	<20 **	

*BE: SGE is legally defined on the regional level

**referring to the definition of thermal (geothermal) water and in case of Austria to the recommended maximum injection temperature for OLS

8.2 Regulations on use of SGE

The GSOs in Europe are rather not involved in regulating the use of SGE, however at least some of them have a role in the official licensing procedures including the controlling and legal consulting. The situation is different when it comes to the assessment of the current legal regulations and influencing, improving the existing legislation and developing the new laws. Involvement of the GSO in legislation on SGES is shown in Fig. 2 and Fig. 3. The legal documents regulating SGE cover a relatively high number of diverse areas – all together 18 (Tab. 9, Fig. 4 and Fig. 5).

The national geological survey of Spain shows quite extensive competences with respect to legislation on SGE. It is involved in enforcement of law and legal regulations, controlling, legal consulting, assessment of legal regulations and with all of these capabilities it can influence improvement and development of new legislation on national level.

Other GSO examples which have some role in the legislative processes are GBA who supports regional authorities in providing information and amending licensing procedures in Austria and BRGM who elaborates the geothermal maps including diverse regulation zones at national and regional levels in France but does not have any legislative role in SGE regulation. For a given location, the classification accounting for geological and hydrogeological specifics is provided along with the description of the predominant risks.

Considering the legal regulations and other documents in the surveyed countries, both obligatory and recommended instruments exist on all three levels, i.e. national, regional and local. Here, the obligatory instruments are understood as those explicitly required by law, while the recommended ones are identified and suggested by other documents such as the sets of recommendations and best practices. Significantly, on all levels many countries have legally binding regulations, while the numbers of countries with recommendations only is lower. This situation is illustrated in Fig. 3. The responding partners emphasize importance of the guidelines and handbooks as crucial for disseminating professional knowledge and increasing public awareness on the SGE applications as well as improving quality of the appropriate activities in the market.

The partners' responses reveal that the available guidelines focus mainly on the technical and engineering aspects of SGES, including design of installation, drilling, building and construction works. The other considerable group covers recommendations and best practices for the environmental

requirements especially in terms of water management as well as quantity and quality control for the OLS. These kinds of guidelines and recommendations (also included in national standards) are for example available for Austria and Sweden, where for the earlier the guidelines on the SGE use have been prepared by a non-government organization, while for the latter two handbooks have been elaborated and published by the GSO (SGU). The Polish GSO (PIG-PIB), within the framework of the project Geothermal4PL, translated two GeoTrainet handbooks, i.e. *GeoTrainet Training Manual for Drillers of Shallow Geothermal Systems* and *GeoTrainet Training Manual for Designers of Shallow Geothermal Systems* as well as the mentioned SGU's handbook *Normbrunn –16. Vägledning för att borra brunn*, and made publically available (on line as the .pdf files). The Polish translations are also disseminated during the professional and sectoral events. On the other hand, the handbooks including the guidelines in the field of legal issues connected with SGE are normally not widely accessible. The guidelines related to permitting and licencing systems have been reported for the United Kingdom only.

Reported guidelines and handbooks are usually provided by different stakeholders. Commonly, those are elaborated by the state standardization bodies, ministries, NGOs or private sector, often in co-operation with the GSO. The guidelines provided by environmental agencies have been reported in two cases – for Denmark and the United Kingdom.

In the surveyed countries the CLS and OLS differ significantly in terms of legal status. The SGE legal regulations are to a major extent driven by the EU legislation including regulations on the direct use of (ground)water in case of OLS along with Water Framework Directive and Groundwater Directive. In several countries, such as Croatia, Czech Republic, France, Spain and the United Kingdom the CLS are normally not regulated and do not require any permits. In Austria and Belgium some simplified legal procedures for CLS have been adopted. Further differences between CLS and OLS exist for example in the Netherlands (different authorisation levels), Denmark, Poland and Slovakia (different legal acts and requirements). In case of OLS the water related legislation is applicable in majority of the project partner countries, where the procedures have to follow the national regulations derived from environmental, geological, mining and construction laws, even if they are not directly related to SGE installations.

The concept of simplified legal regulations and administrative procedures is rather commonly implemented in the project partner countries, taking into account that different criteria might be implemented, for example the water volume (less than 10 m^3/h for the Netherlands), max installed power (<70 kW for the Netherlands and <500 kW for France), depth (between 10 and 200 metres for France), etc. The maps of the sensitive areas and suitability for construction of SGES can be a useful tool for determination and delineation of the areas characterized by different legal requirements. In France, special maps were prepared based on the adopted risk factors concept. These are in use to qualify the individual investment sites into a proper legal regime, for example indication of the areas suitable or not for simplified procedures of SGES construction). In Austria, the mapping concept is used to determine for example the sensitive areas in terms of occurrence of artesian groundwater zones and protected groundwater areas as well as the settlements without a centralized water supply system. In Poland, suitability mapping for SGES is somewhat similar to mapping in Austria and has been developed based on the outcomes of the TransGeoTherm, Geothermal4PL and GeoPLASMA-CE projects. The mapping tools enhance better qualification of the SGES investment sites and help to implement the relevant legal requirements and administrative procedures. Typically, the geothermal

maps ought to present areas under special protection, like national parks and nature reserves, drinking water protection zones, cultural or natural monuments, etc., where some additional obligations need to be met and different permits may be required.

In most surveyed countries the same legal regulations are binding for the whole territory. An example of locally implemented requirements applicable for SGE was reported for ES, where at the regional level, the competent authorities introduced the provisions into the River Basin Management Plans, in order to maintain valuable thermal quality of the groundwater bodies, including maximum relative temperature change values between extraction and injection wells between 6 to 8^{o}C, and maximum temperature thresholds of 30^{o}C.

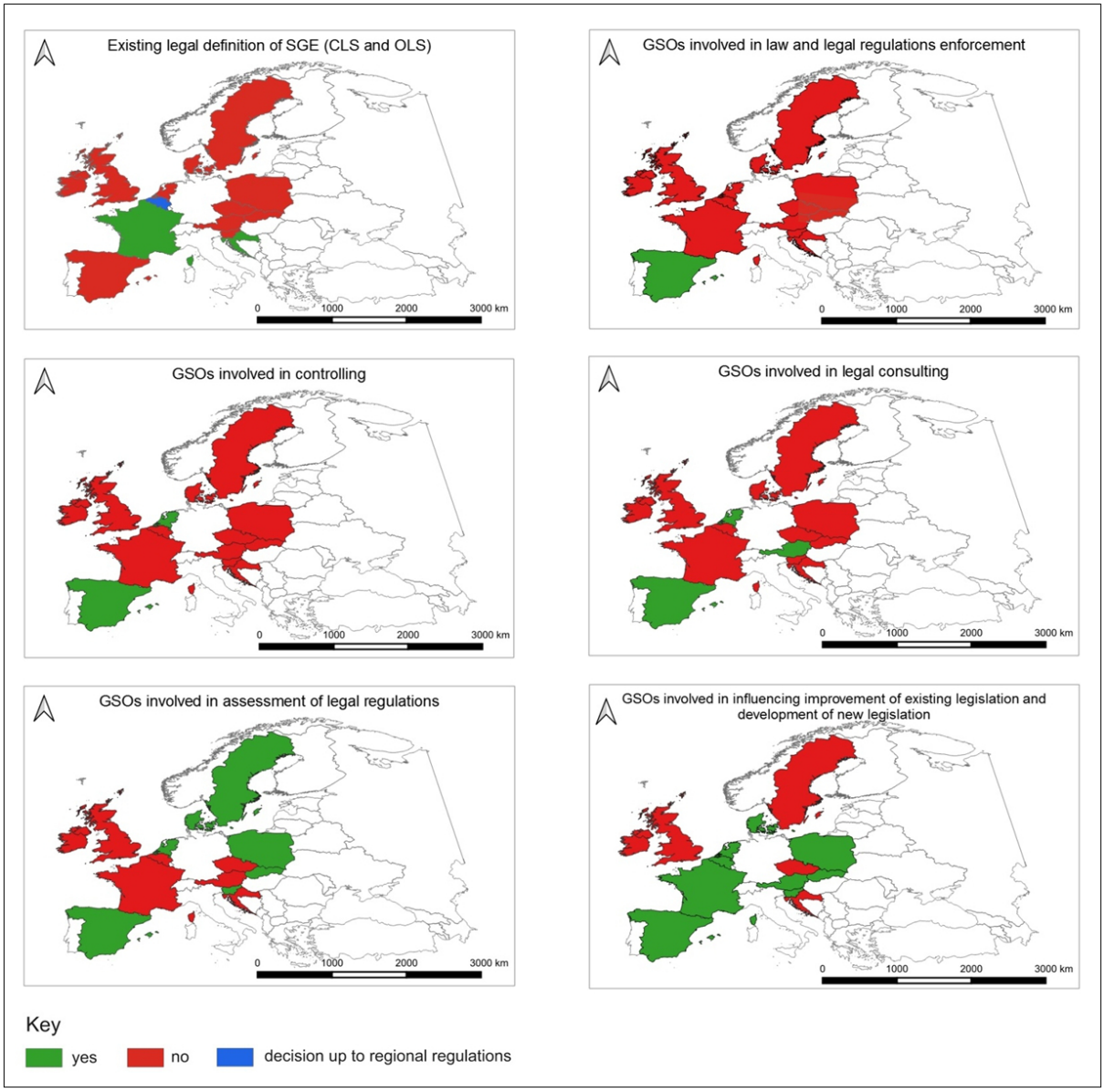


Fig. 2 Existing SGE definitions and role of GSOs in national legal regulation processes

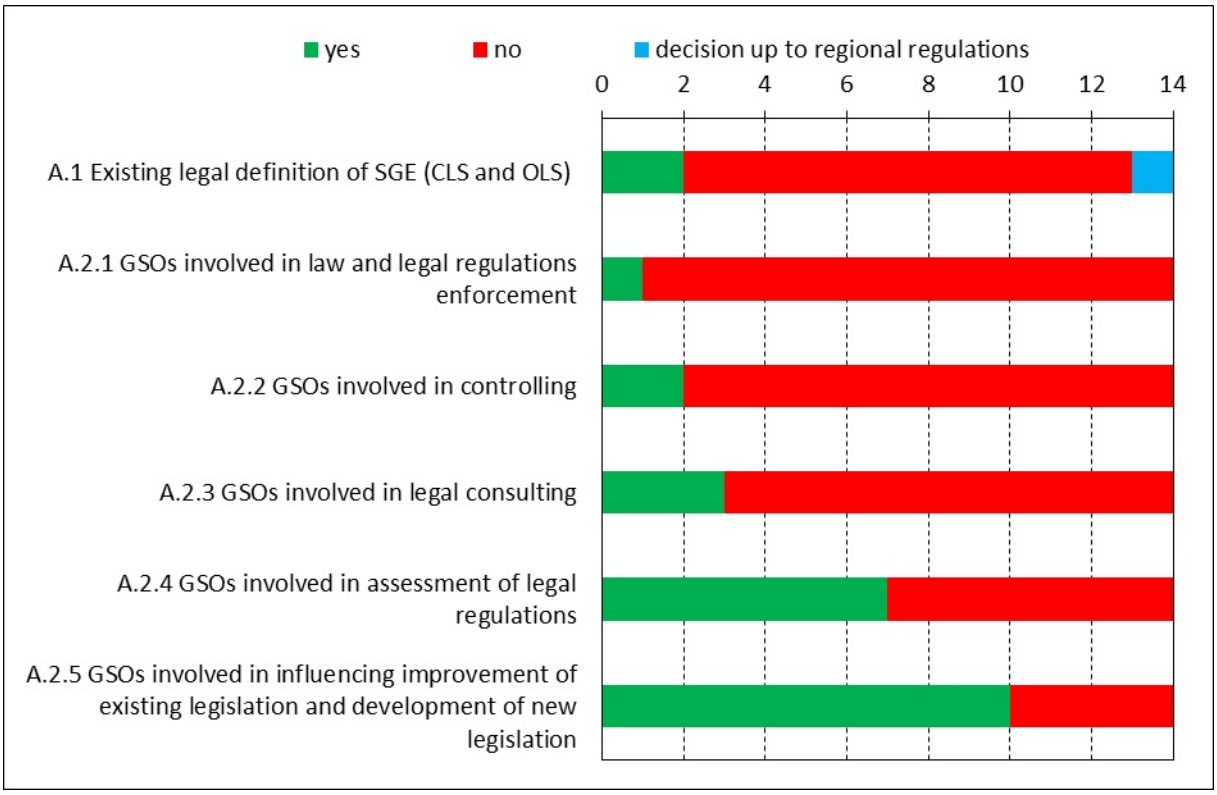


Fig. 3 Summary of partners' feedback on legal regulations on SGE

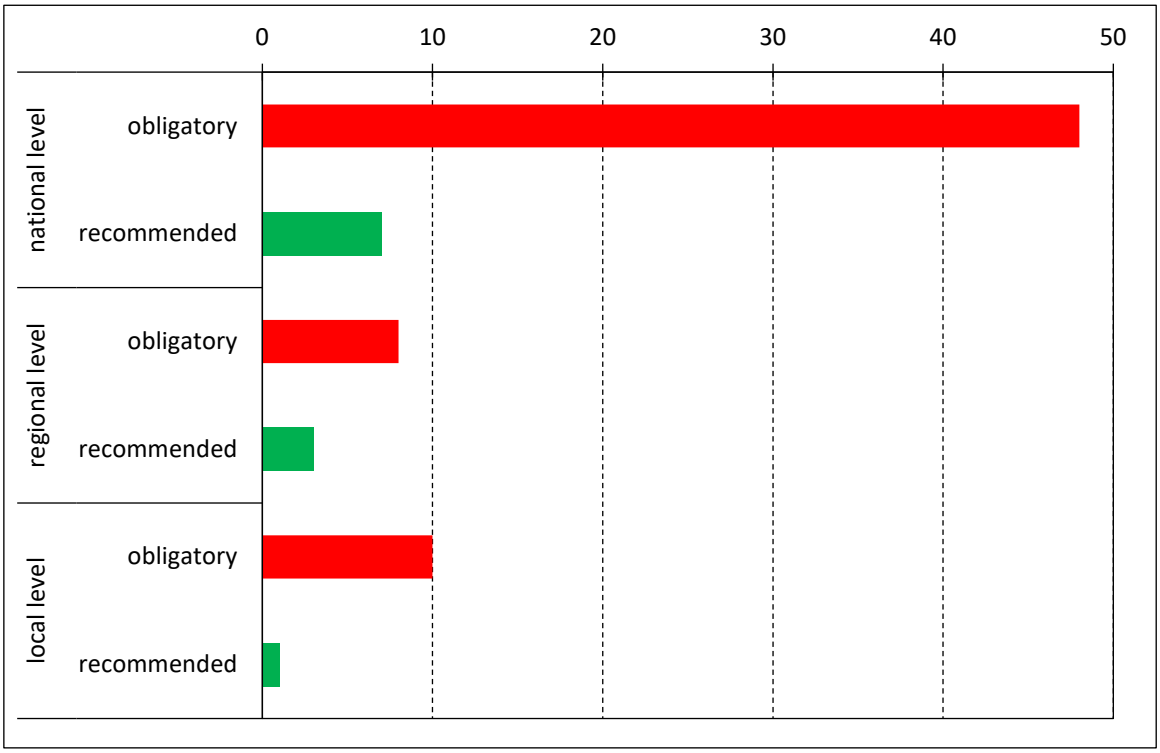


Fig. 4 Summary of partners' feedback on obligatory vs. recommended legal instruments on national, regional and local level

Fig. 5 Summary of partners' feedback on legal binding regulations and non-binding guidelines on SGE in partner countries. IE – no feedback received

Tab. 9 Areas of legal regulations and non-binding guidelines for SGE

Project partner Country	P01 AT	P02 UK	P04 HR	P05 CZ	P06 FR	P07 IE	P08 BE	P09 SI	P10 ES	P11 SE	P12 NL	P13 PL	P14 SK	P16 DK	TOTAL LR	TOTAL GD	Comments
Water	LR	LR	LR	LR	LR	LR		LR	LR		LR	LR	LR	LR	**12**	**0**	IE: not clear at the moment – abstraction **registration** is a requirement, but how it will be licensed is not clear
Mining	LR				LR			LR	LR		LR	LR			**6**	**0**	
Geology				LR								LR	LR	GD	**3**	**0**	PL: *Geology and mining law act* applies to drilling >30 m, drillings deeper than 100 require programme of mining operations
Construction	GD		LR	LR				LR	LR			LR		GD	**5**	**0**	
Environmental protection	GD	LR			LR	LR		LR	LR			LR		LR	**6**	**0**	
RES and energy efficiency			LR									LR	LR	GD	**3**	**0**	IE: part L of building regulations require minimum % of renewable energy technology. RE includes geothermal but not only geothermal (e.g. Solar PV, biomass etc. as well)
Subsurface energy											LR			GD	**1**	**0**	IE: no legislation currently (draft heads of bill were drafted but not progressed/passed into law)
Spatial planning						GD						LR			**1**	**0**	IE: renewable use encouaraged
Water protection zones	LR			LR	LR		LR	LR					LR		**6**	**0**	BE: groundwater for Brussels-Capital Region
Protection against flooding				LR									LR		**2**	**0**	
Drilling and well design	GD				LR		LR			LR		GD		LR	**4**	**1**	SE: recommended

Project partner Country	P01 AT	P02 UK	P04 HR	P05 CZ	P06 FR	P07 IE	P08 BE	P09 SI	P10 ES	P11 SE	P12 NL	P13 PL	P14 SK	P16 DK	TOTAL LR	TOTAL GD	Comments
SGE design and installation	GD	LR			LR							GD			**2**	**1**	UK: only OLS are regarded, CLS are not regulated
OLS & ATES	GD				LR		LR							LR	**3**	**1**	FR: online declaration for certain type of installations
CLS & BTES	GD				LR				LR					LR	**3**	**1**	FR: online declaration for certain type of installations ES: recommended
RES installers certification	LR		LR			LR								LR	**4**	**0**	IE: if refrigerants used, then registered fitter must be used. For other installations, no current cert scheme
Water discharge	LR					LR					LR			LR	**4**	**0**	IE: discharge license required for direct discharge to SW body or sewer. Reinjection to groundwater no LRs known NL: discharge outside SGES infrastructure
River Basin Management Plans									LR			GD			**1**	**1**	
Local regulations									LR			LR			**2**	**0**	ES: drilling permits PL: land use planning
TOTAL LR	**5**	**3**	**4**	**5**	**7**	**4**	**3**	**5**	**7**	**1**	**4**	**8**	**5**	**7**	**68**		
TOTAL GD	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**		**5**	

LR – legal regulations (obligatory)

GD – non-binding guidelines describing state-of-the-art (recommended)

8.3 Application for SGES installations and licensing (permitting)

The licensing procedures applied to SGES were reported for most project partner countries, while no permitting and/or licensing procedures for Croatia, Czech Republic, Ireland and Sweden. In Belgium, Denmark, the Netherlands and Poland the official application is followed by the permitting and/or licensing procedures for both CLS and OLS, while in Slovakia and the United Kingdom for OLS only. In Austria, France and Spain the application and licensing procedures differ from case to case and depend upon the installation type and other individual criteria. In case of Austria the legal basis is the same for the entire country, however the interpretation of the environmental impact allows for certain flexibility at the level of local authorities regarding the use of CLS. In contrast, licensing procedures for OLS are mandatory and regulated in the same way in all parts of Austria. The results of the partners' questionnaire referring to the application procedures for SGES installations and licensing and/or permitting are illustrated in Fig. 6 and Fig. 7, for CLS and OLS respectively.

Commonly, the application procedures are the same for the whole country and in terms of the applicant type. In the United Kingdom, however, the procedures vary slightly between the individual countries, e.g. in England and Wales one can abstract water volume of 20 m^3/d without a licence, while in Scotland only 10 m^3/d. In Belgium, the Netherlands and Spain some differences between the regions in terms of detailed regulations have been reported as well. Some differences in the application procedures depending on the type of the applicant have been reported for the Netherlands, though the details have not been given.

Duration of SGES application, administrative proceeding and granting the license is usually legally regulated. It has been reported for Slovakia and Spain that despite the general rules and regulations, no specific time period has been established for the duration of the licensing procedure. The period of time the licence is granted for is legally regulated in Austria, where it is limited to 25 years, although the licensing authority is empowered to define shorter or longer periods. In case of a simplified notification procedure related to BHEs, the licensing period is limited to 15 years if not specified differently by the authorities. Also in Belgium, Slovenia, Slovakia (OLS), Spain and the United Kingdom the license is granted for a particular period of time. The project partners from Denmark, France and Slovakia (CLS) have reported that the length of the license is not legally regulated. What needs to be emphasized, six respondents have reported availability of the on-line application procedure in their countries.

In terms of fees related to the SGES application procedures, no fees for proceeding the application and granting the permit and/or licence, were reported for Czech Republic, Denmark, France, Slovakia and Sweden. In case of Poland, the fees apply to the water permits needed for OLS. Fees for both systems connected to proceeding of the application and granting the permit/licence were reported for the following countries: Croatia, the Netherlands, Slovenia, Spain and the United Kingdom. In Austria and Belgium, there are no fees associated with application process itself, however there are some fixed fees for granting the license/permit.

In general, GSOs are not involved in terms of assessing, proceeding or granting the licenses for SGES, except for IGME in Spain and TNO in the Netherlands. IGME plays an important role in the process of monitoring of environmental impacts and system exploitation regimes. It is obliged to identify thermal interferences between the individual systems, propose the sustainable temperature threshold values,

such as maximum injection temperatures and relative extraction/injection temperature differences and publishes the official reports. TNO is involved in assessing the SGES applications.

According to the reported situation regarding the ownership, the land owner is the only owner and user of the SGE resources in Austria, Croatia, Czech Republic, Poland and Slovakia.

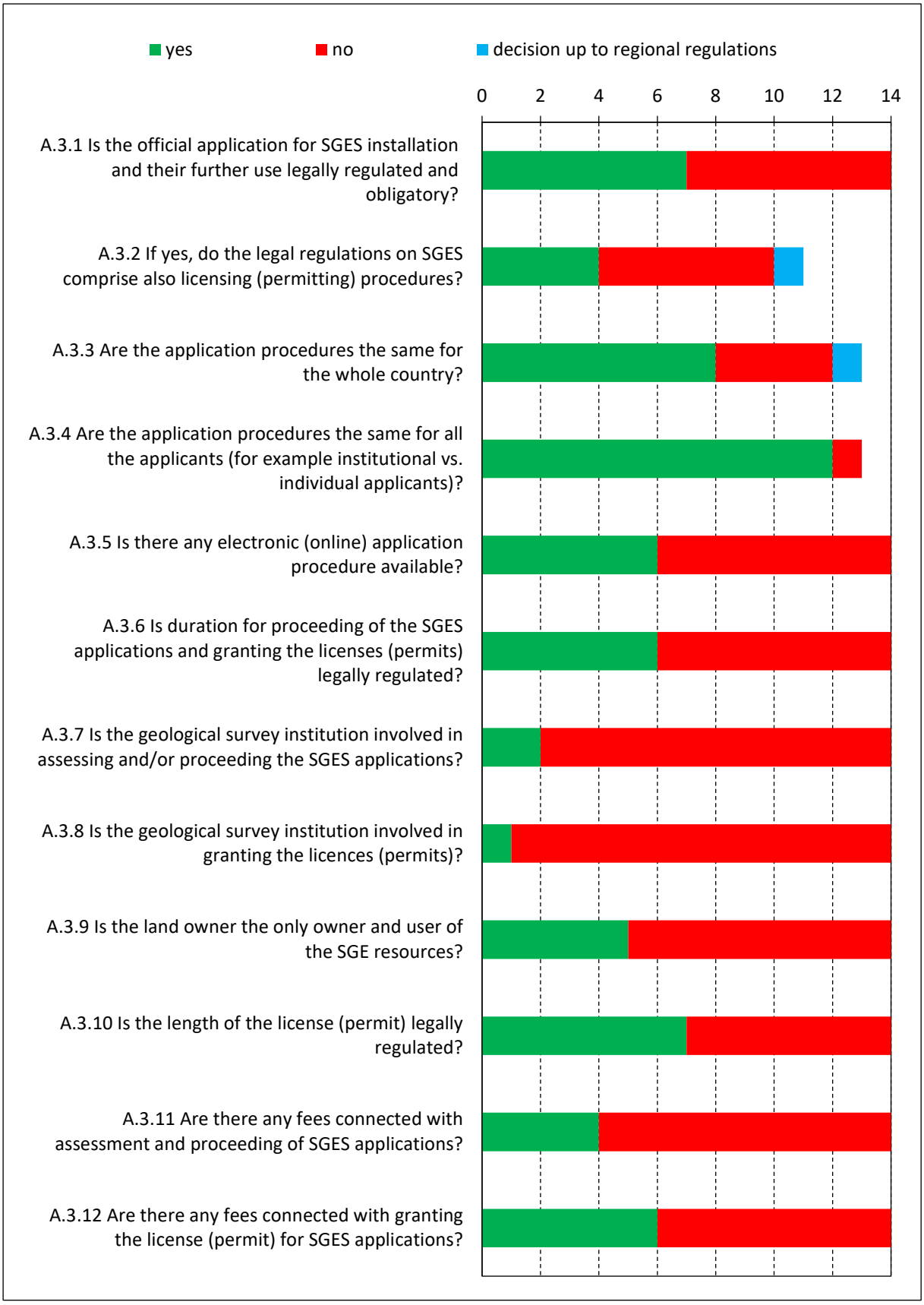


Fig. 6 Summary of partners' feedback on application procedures and licensing on SGES for CLS

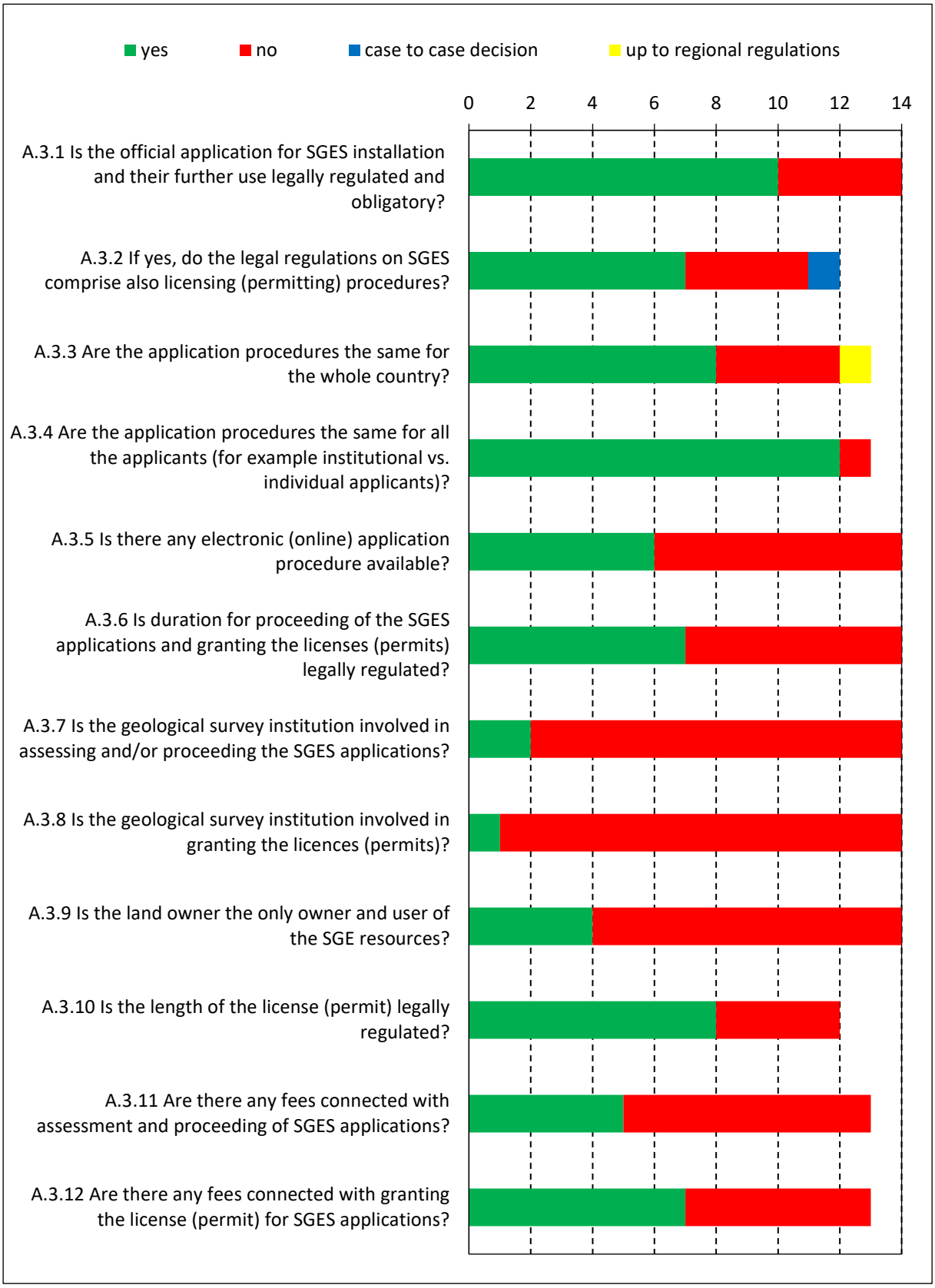


Fig. 7 Summary of partner's feedback on application procedures and licensing on SGES for OLS

8.4 Facilitating measures of application procedures for SGE installations

The RED II Directive (Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources), Article 15, refers directly to the application procedures for SGE installations. It states that *the EU member states shall ensure that any national rules concerning the authorisation, certification and licensing procedures that are applied to plants and associated transmission and distribution networks for the production of electricity, heating or cooling from renewable sources… are proportionate and necessary and contribute to the implementation of the energy efficiency first principle.* According to the directive, the member states shall ensure that:

- *administrative procedures are streamlined and expedited at the appropriate administrative level and predictable timeframes are established*;
- *rules concerning authorisation, certification and licensing are objective, transparent and proportionate, do not discriminate between applicants and take fully into account the particularities of individual renewable energy technologies*;
- *administrative charges paid by consumers, planners, architects, builders and equipment and system installers and suppliers are transparent and cost-related*;
- *simplified and less burdensome authorisation procedures, including a simple-notification procedure, are established for decentralised devices, and for producing and storing energy from renewable sources*.

Feedback to the partners' questionnaire allowed for identification of national regulations applied by the project partner countries to ensure the national regulations comply with the RED II Directive. In several countries some facilitating measures, such as one-stop shop procedure, e-government (electronic and online applications), short and limited application proceeding time period, simplified application for small scale units, e.g. family housing, limited or no fees, no additional charges, have been implementation into the SGES licensing procedures. Those are characterised in Tab. 10. Often the facilitating aspect of each measure depends to a large extent on the national legal context and differs significantly from country to country. It must be emphasized that licensing is not obligatory in several studied countries for both CLS and OLS and, in addition, it does not explicitly influence development of SGE market, e.g. Sweden. Lack of obligatory licensing might be in some countries regarded as a facilitating measure, however in some cases it would cause substantial negative consequences to further operation of the SGE installations. Further on, two other measures, i.e. 2. Land owner owns SGE resources and 8. Unlimited license length could be also regarded as a barrier, depending on conventional legal system and resulting accustomed administrative regulations.

In France, a simplified online declaration for SGE installations is possible, for closed and open loop systems, depending on criteria of depth, power, flow rates and regulation zones maps. Through this simplified procedure, the exploitation is not limited in time. However, when the installation differs from those criteria, a licensing is required and simplified online application is not valid anymore. The

authorization permit is delivered by the DREAL (a regional authority) after a file application has been reviewed. The license is then granted for a limited amount of time.

Generally, the application procedures are to some extent less complex for CLS than for OLS (Tab. 11 and Tab. 12, Fig. 8 and Fig. 9, respectively), which could be attributed to limited influence of CLS on groundwater and thus constrained possible environmental impact. The facilitating measures the most often applied to CLS and OLS licensing procedures are: *no application fee* and *no licence fee*. Important identified measures are also: *unlimited license length* for CLS and *max time limit to issue a licence* and *online application*, for OLS. It should be highlighted that the following facilitating measures: o*ne-stop shop* and *online application* are still not employed to a sufficient degree. Implementation of measures connected with electronic means as well as use of possibilities provided by the Internet and electronic mail seems to be less complicated and more straightforward, while it would provide possibility for application from a distance, without submitting paper documents.

Tab. 10 Facilitating measures on application procedures for SGE installations identified by MUSE

#	Facilitating measure	Description
1.	Obligatory licensing	Licensing system for SGE installations is obligatory .
2.	Land owner owns SGE resources	The owner of a ground plot where the installation is placed is the only owner of the SGE resources possible to extract. In some countries this measure is not regarded as facilitation – to the contrary as a barrier.
3.	One-stop shop	A one-stop shop, one-stop store or one-stop source is a business or office where multiple services are offered, i.e. customers can get all they need in just one stop. In a legal context means that only one authority is in charge of coordination of the SGE licensing procedures and in consequence is responsible for granting the licence.
4.	Online application	Possibility to fill in and submit the application for SGES operation online, through the Internet, without submitting application on paper.
5.	Self-starting permission or licence	Permission or license for operation of SGE installation starts itself after a certain deadline, in case the duly submitted application has not been assessed by a licensing institution. In such circumstances a so-called *silent permission* is in fact granted and construction of CLS or OLS may start.
6.	Facilitations for small units	Simplified procedures available for smaller units, e.g. installation below a certain capacity, usually installation for a single family house, etc.
7.	Max time limit to issue a licence	The administrative procedure of assessing the application and granting a permit or a licence for SGES operation is time limited and cannot take longer than a defined period of time after which the administrative decision on permission must be officially issued.
8.	Unlimited license time span	The length of the licence time span for operation of SGE installation is not limited thus there is no need to reapply for licence in case of the same properly working installation, normally CLS. With regard to sustainability the license should be however granted at least for the payback time of the investment or 1.5 times the payback time and then re-evaluated concerning the state-of-the-art. In some countries this measure is not regarded as facilitation, to the contrary as a barrier. On the other hand it should be emphasized that in case of OLS the time span of licenses and permits are normally time limited as the aquifer boundary conditions and other settings may change over exploitation time.
9.	No application fee	There is no fee connected with submit ion and assessment of application for operation of SGE installation
10.	No license fee	There is no fee connected with granting a permission or a license for operation of SGE installation

Tab. 11 Obligatory licensing vs. identified facilitating measures of application procedures for CLS installations

PP country	P01 AT	P02 UK	P04 HR	P05 CZ	P06 FR	P07 IE	P08 BE	P09 SI	P10 ES	P11 SE	P12 NL	P13 PL	P14 SK	P16 DK	TOTAL yes	TOTAL no	N/A
1. Obligatory licensing	yes	no	no	no	yes	no	yes	no	yes	no	yes	yes	no	yes	7	7	0
2. One-stop shop	yes	N/A	N/A	yes	yes	no	yes	no	yes	N/A	yes	yes	no	no	6	5	3
3. Online application	no	N/A	N/A	no	no	N/A	yes	yes	no	N/A	yes	no	no	yes	4	6	4
4. Self-starting permission	yes	N/A	N/A	no	no	no	no	no	no	yes	no	yes	no	no	4	8	2
5. Facilitations for small units	yes	N/A	N/A	yes	no	no	yes	yes	N/A	yes	yes	yes	no	no	7	4	3
6. Max time limit for procedures	yes	N/A	no	no	no	no	yes	no	no	N/A	yes	yes	no	yes	5	7	2
7. Land owner owns SGE resources	yes	no	yes	yes	no	yes	yes	no	no	no	no	yes	yes	no	7	7	0
8. Unlimited license time span	no	N/A	yes	yes	no	N/A	yes	yes	no	N/A	no	no	yes	yes	6	5	3
9. No application fee	yes	N/A	yes	yes	yes	N/A	no	yes	yes	N/A	no	yes	yes	yes	9	2	3
10. No license fee	yes	N/A	yes	yes	yes	N/A	no	yes	yes	N/A	no	yes	yes	yes	9	2	3
TOTAL yes	**8**	**0**	**4**	**6**	**4**	**1**	**7**	**5**	**4**	**2**	**5**	**8**	**4**	**6**	**64**		
TOTAL no	**2**	**2**	**2**	**4**	**6**	**5**	**3**	**5**	**5**	**2**	**5**	**2**	**6**	**4**		**53**	
N/A	**0**	**8**	**4**	**0**	**0**	**4**	**0**	**0**	**1**	**6**	**0**	**0**	**0**	**0**			**23**

N/A - not applicable

BE: regulations binding in the Brussels-Capital Region

Tab. 12 Obligatory licensing vs. identified facilitating measures of application procedures for OLS installations

PP country	P01 AT	P02 UK	P04 HR	P05 CZ	P06 FR	P07 IE	P08 BE	P09 SI	P10 ES	P11 SE	P12 NL	P13 PL	P14 SK	P16 DK	TOTAL yes	TOTAL no	N/A	Partly
1. Obligatory licensing	yes	yes	yes	no	yes	no	yes	yes	yes	no	yes	yes	yes	yes	11	3	0	0
2. One-stop shop	yes	no	no	no	yes	no	yes	no	yes	N/A	no	no	no	no	4	9	1	0
3. Online application	no	yes	no	no	no	N/A	yes	yes	yes	N/A	yes	no	no	yes	6	6	2	0
4. Self-starting permission	no	no	no	no	no	no	no	no	No	N/A	no	yes	no	no	2	11	1	0
5. Facilitations for small units	no	no	no	no	no	partly	no	yes	Yes	N/A	yes	no	no	no	3	9	1	1
6. Max time limit for procedures	no	yes	yes	no	no	no	yes	no	no	N/A	yes	yes	no	yes	6	7	1	0
7. Land owner owns SGE resources	yes	no	no	yes	no	yes	yes	no	no	no	no	yes	no	no	5	9	0	0
8. Unlimited license time span	no	no	no	yes	no	N/A	yes	no	no	N/A	yes	no	no	yes	3	9	2	0
9. No application fee	yes	no	no	yes	yes	N/A	no	no	no	yes	no	yes	yes	yes	7	6	1	0
10. No license fee	yes	no	no	yes	yes	N/A	no	no	no	N/A	no	yes	yes	yes	6	6	2	0
TOTAL yes	**5**	**3**	**2**	**4**	**4**	**1**	**6**	**3**	**4**	**1**	**5**	**6**	**3**	**6**	**53**			
TOTAL no	**5**	**7**	**8**	**6**	**6**	**4**	**4**	**7**	**6**	**2**	**5**	**4**	**7**	**4**		**75**		
N/A	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**7**	**0**	**0**	**0**	**0**			**11**	
Partly	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**				**1**

N/A - not applicable

BE: regulations binding for the Brussels-Capital Region

SI: facilitations for small units <16kW

ES: permission is always required

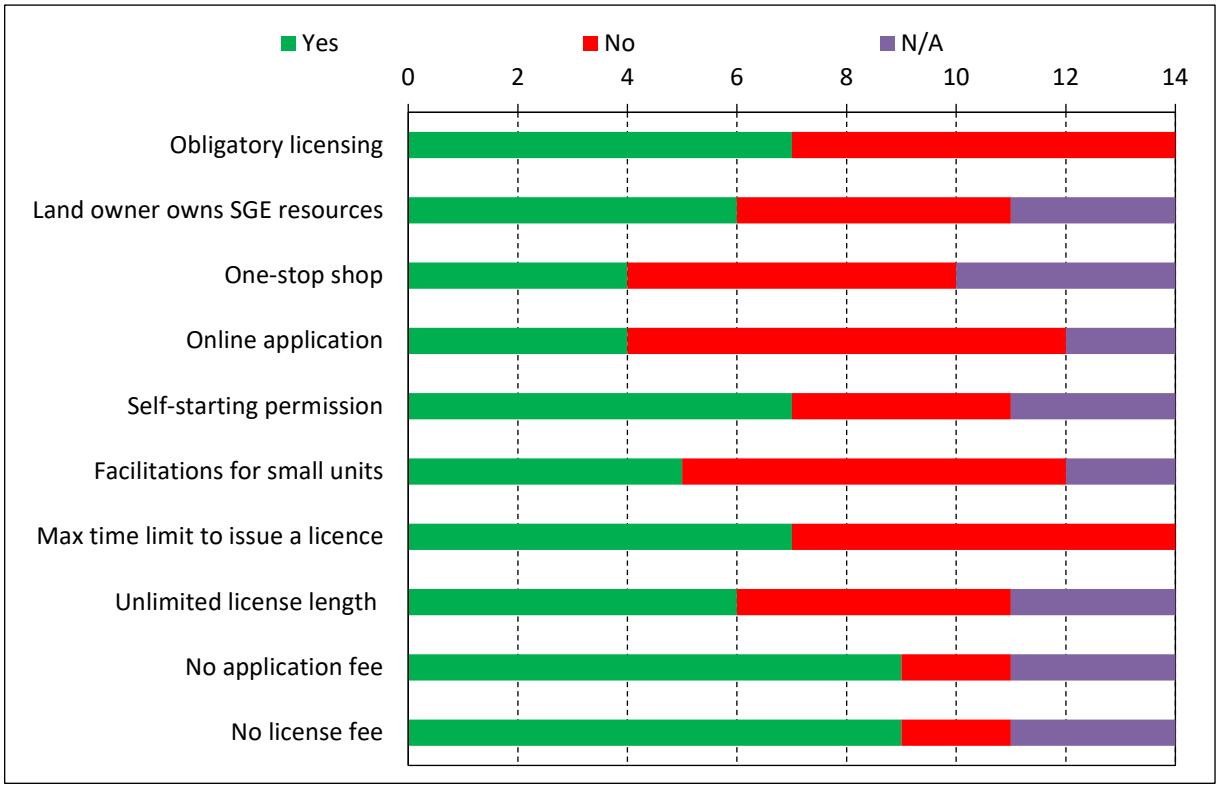


Fig. 8 Summary of partners' feedback on obligatory SGE licensing and selected facilitating measures for CLS licensing procedures

Fig. 9 Summary of partners' feedback on obligatory SGE licensing and selected facilitating measures for OLS licensing procedures

8.5 Register of SGE installations

A register of SGE installations exists in the following researched countries: Belgium, Denmark, France, the Netherlands, Sweden and the United Kingdom, while in Austria and Slovakia it depends on regional regulations. For some countries, it was reported that there was not central register of SGE installations, however the regional and/or local authorities kept their own registers (e.g. Denmark, Poland). In some countries (i.e. Austria, Poland, Slovakia) all the wells, including those of OLS must be registered according to legal regulations on water, including groundwater. Only in some cases, i.e. Belgium, the Netherlands, Sweden and the United Kingdom the register is comprehensive and regularly updated. Ordinarily, if register exists it is publically available, with exception for Denmark, the Netherlands and the United Kingdom. Involvement of the interviewed GSOs in running the register is limited to BRGM in France and SGU in Sweden. Among all interviewed project partners the lack of comprehensive and regularly updated register of SGE installations was indicated as a barrier for development of SGE market for the following countries: Austria, Czech Republic, Spain, Ireland, Slovenia and Slovakia. The number of SGE installations is usually estimated based on heat pump sales data (Austria, Ireland, Poland and Slovakia). For Denmark the other barriers such as economy and central heating regulations are indicated to be of more significant importance. In Poland information about existing SGE installations, including borehole data, can be withdrawn from the geological archives and data bases, however those do not include all installations. The summary of project partners' questionnaire referring to register of SGE installation is shown in Fig. 10.

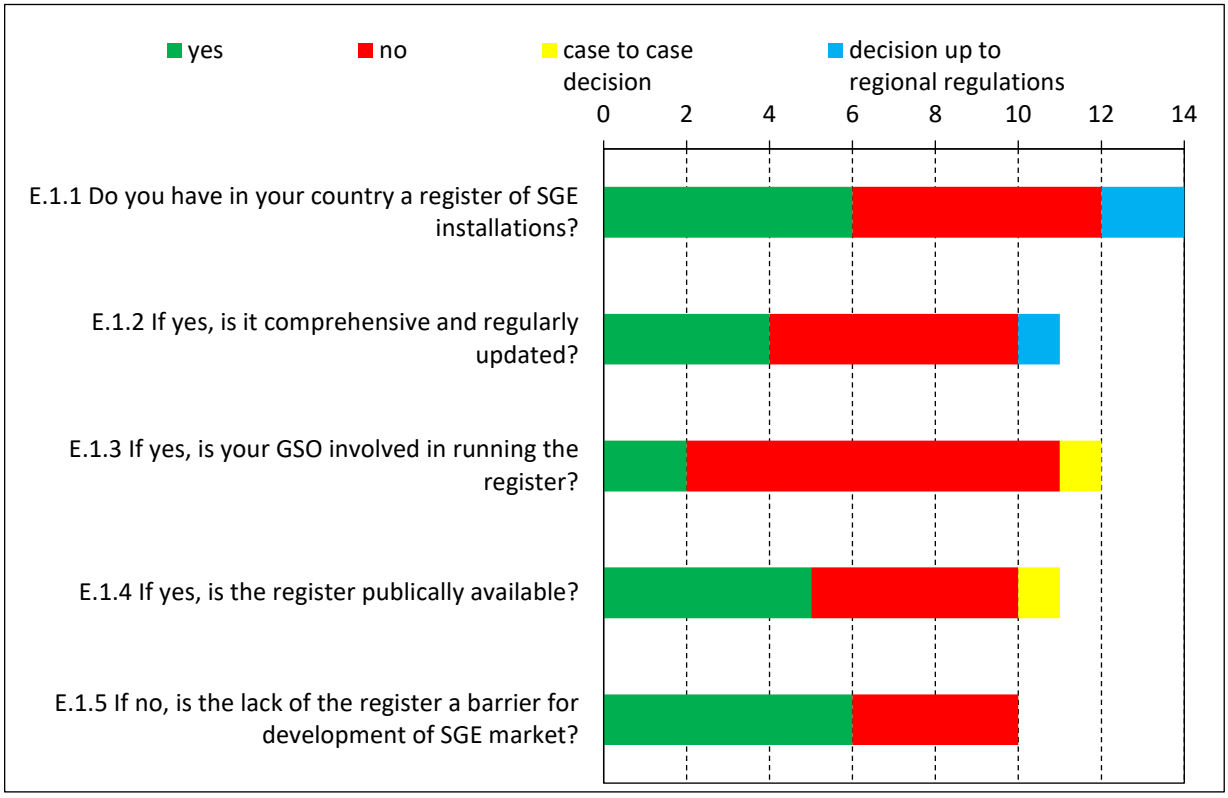


Fig. 10 Summary of partners' feedback on register of SGE installations

8.6 Authorities responsible for assessing applications and granting licenses (permits) for SGES

The process of assessing the applications and granting the licenses and/or permits for SGES installations involves diverse authorities of the surveyed countries which are usually corresponding with administrative division as well as the level of competences and regulations dedicated to SGE. For example, in Croatia and Slovakia the national authority is involved, as there are no additional regulations for SGE on different level. The water authority in Croatia (Hrvatske vode) and Slovakia (Ministry of Environment for utilization exceeding 15 000 m^3/year) assesses the OLS equipped with GWHPs, with regulations being the same as for any other water well in the country. In Belgium, France and the United Kingdom only the regional environmental authorities are involved. In Austria and Sweden, only the local authorities are involved. In case of Czech Republic, the environmental offices of the regional authorities as well as the local building and water protection authorities are responsible for the permitting system. The situation is similar in Slovenia, where the local building and water protection authorities participate in this process with involvement of the state water protection authority - Water Agency in Slovenia. In Denmark and Slovenia, the authorities on regional level are not engaged , while in the Netherlands, Slovakia and Spain the national, regional and local authorities participate in the assessing and granting process. In most cases, the municipalities or local district offices participate in the process of assessment of the applications and granting the licences/permits. It must be emphasized that due to the direct use of groundwater in case of the OLS the environmental and water agencies are normally involved in most of the surveyed countries. Fig. 11 illustrates authorities responsible for assessing the applications and granting the licences and/or permits for SGE installations who provide additional information and explanations to the applicants. This is a case for Austria, Belgium, Denmark, France and the Netherlands, where the authorities in charge offer support and information.

The GSOs of Austria, Czech Republic, Poland and the United Kingdom are not involved in any licensing procedures. IGME in Spain advises the public administration when required. Similarly, in the Netherlands, where the authorities responsible for licencing and permitting with respect to SGE installations may benefit from the expertise of the GSOs. SGU in Sweden is involved only when assessing SGEs within the water protection areas. BRGM, in cooperation with ADEME (French Environment & Energy Management Agency) provides technical guidance regarding procedures for SGE installations in France, e.g. website, brochure, training courses, etc.

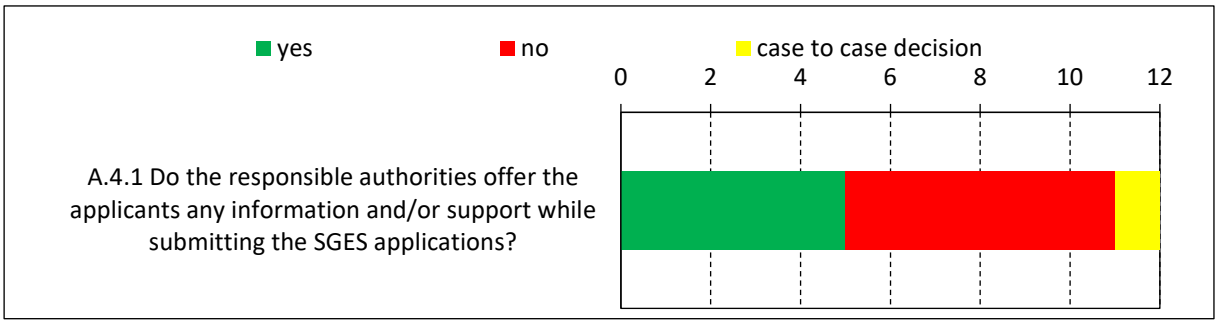


Fig. 11 Summary of partners' feedback on authorities responsible for assessing the applications and granting the licences and/or permits for SGES

8.7 Requirements for operation of SGES

The permit or license provided by the authority always limits the operations of the SGE installation. The established limits may refer to maximum pumping rate, daily and annual production rates, maximum and minimum injection temperatures as well as maximum admissible temperature shifts between the production and injection wells (for OLS). Usually, there are no specific limitations given to CLS except for the recommended minimum and maximum inlet temperatures into the BHE. The summary of requirements for operation of SGES for CLS and OLS are illustrated in Fig. 12 and Fig. 13, respectively.

The legal requirements and/or recommendations by the authorities for the SGES operations are not provided in Czech Republic, Croatia, France, Ireland, Slovakia, Slovenia, Sweden and the United Kingdom. In Austria, no legal requirements for the installation and operation of CLS are given, though the recommended minimum and maximum inlet temperatures into the BHE must be obeyed, while for OLS the conditions are limited by the obtained permit. Licencing is in line with state-wide permission policy, which is based on nationwide recommendations. In Spain, the total volume of water and transferred energy are controlled and limited. In the Netherlands, a performance report referring to produced and stored energy needs to be submitted to the local authorities via the online platform. Any anomalies or interruptions should be reported either to the inspector or through the online platform. For the OLS the monitoring data on temperature, pH and flow rates are collected and submitted to the authorities. In Denmark, the injection temperature is fixed and the abstraction requirements are provided for OLS. For CLS, the minimum input temperature of 0°C is required.

Usually, the GSOs are not involved in the process of application and granting procedures. Only in Spain, IGME is obliged, when required, to inform the water authorities on the sustainability of the intensive SGE exploitation in the urban environments in case of long-term use. Nevertheless, the GSOs are to some extent engaged in development of SGE installations, at least as advisory bodies or offering scientific expertise. GBA in Austria is involved in studies dealing with monitoring of use and consulting the city of Vienna about operational management issues. GBA also has prepared maps of SGE potential for several regions of the country. Similarly, in the United Kingdom, BGS has no official role but it provides the geological data and results of applied research on geology, hydrogeology and ground conditions. In Croatia HGI-CGS takes part in the public debate as any other citizen or institution, however their expertise is by no means required nor does it have to be considered or implemented.

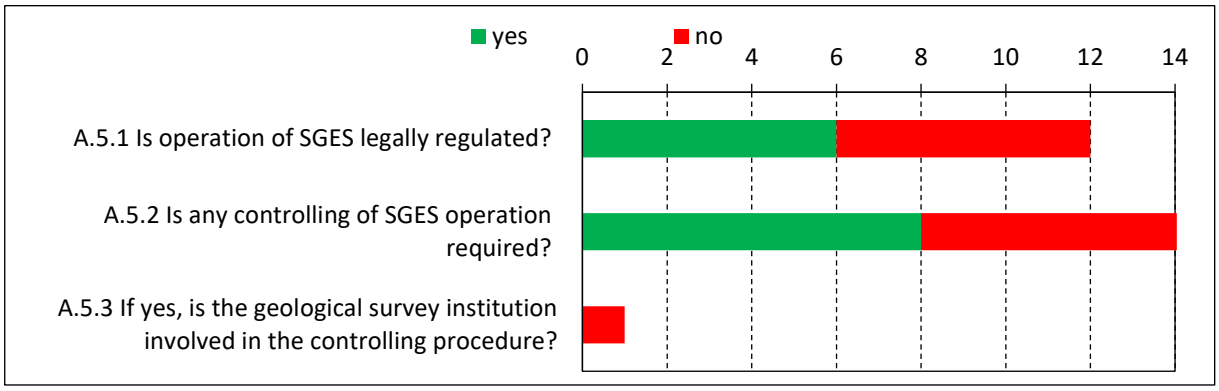
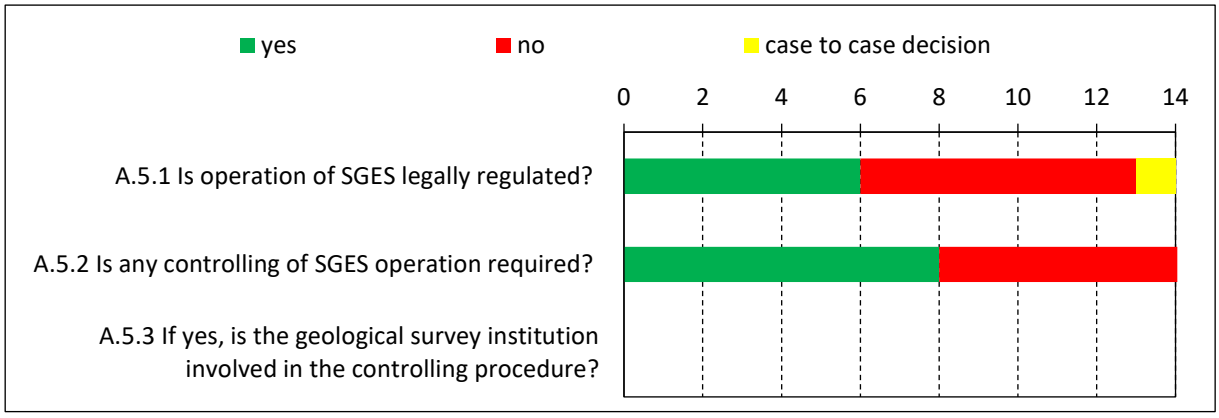


Fig. 12 Summary of partners' feedback on requirements for operation of CLS

Fig. 13 Summary of partners' feedback on requirements for operation of OLS



8.8 Special requirements for installation and operation of SGES

Predominantly, the requirements referring to SGES are uniform in the entire countries for all the project partners which implicate no differences between the national and local levels. Heterogeneous settings are reported for Belgium, where as a rule the regions are responsible for the legal framework on SGE and no regulations exist on national level. In Spain, the additional maximum and relative production/injection temperatures are fixed by the River Basin Management Plans (RBMP) and regulated on regional level. In addition, the national legal framework does not fix a depth threshold for the environmental impact assessment to be conducted for drilling. This, like RBMPs, is also decided and required by the regional authorities. Another exception, reported for Vienna by GBA, refers to the allowed injection temperatures. While the national guidelines recommend maximum injection temperature of 20^{o}C and temperature shifts of up to 6^{o}C between production and injection well, the regional government of Vienna limits the threshold values to 18 and 5^{o}C. In the United Kingdom the best practice and recommendations are different at the national and regional levels. Fig. 14 shows a summary of replies to the questionnaire, part A, closed question no. 6. Special requirements for installation and operation of SGES.

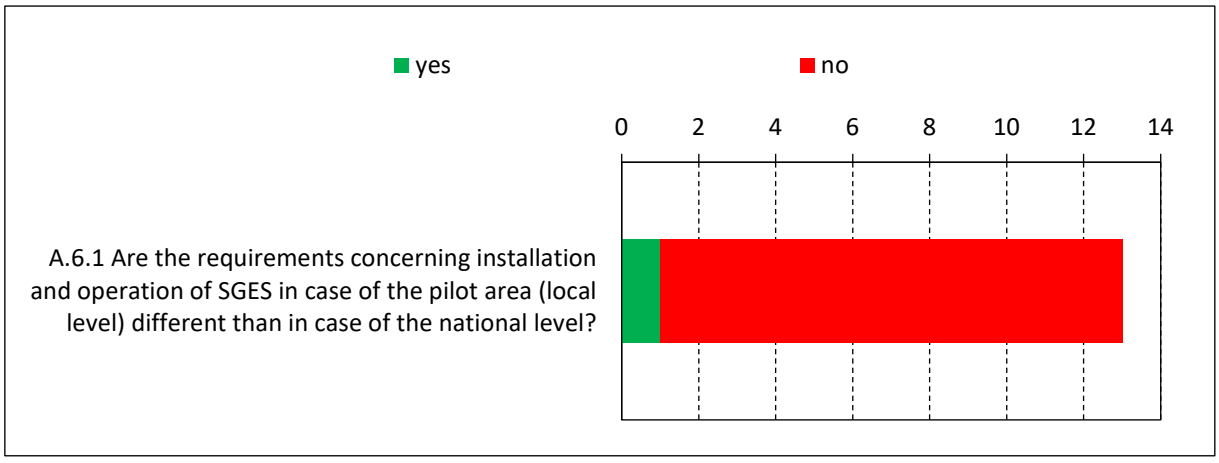


Fig. 14 Summary of partners' feedback on special requirements for installation and operation of SGES

8.9 Decommissioning of redundant boreholes used for SGES

The procedures for decommissioning of redundant boreholes used for SGES are legally established and compulsory in most of the project partner countries. Here, the redundant boreholes are understood as the boreholes and wells which are not in operation any longer, should be abandoned, thus properly decommissioned. Those cover removing selected parts of installations, including casing and backfilling, as well as sealing the top of a borehole, recording the details and informing the competent authorities such as municipalities and regional governments. The primary objective of borehole decommissioning in case of abandonment is preservation of underground conditions with special respect to groundwater, including protection against contamination and prevention of groundwater leakage from the aquifers. The procedures are usually regulated and if no legal framework dedicated to SGES is foreseen the rules resulting from water, geological, mining, environmental and building acts take effect (according to feedback from Slovakia, Slovenia and Spain). The best practices and state-of-the-art procedures may be defined by the non-governmental organizations, i.e. in Austria, or by the governmental entities, e.g. the Environmental Agency in the United Kingdom. Fig. 15 illustrates a summary of replies to the questionnaire, part A, closed question no. 7 referring to decommissioning of the redundant SGES boreholes, while Tab. 13 shows the key aspects of SGES boreholes decommissioning.

Detailed procedures for decommissioning of boreholes used for SGES legally regulated and standardized were reported for France. For CLS, the measures required at the end of exploitation are as follows: verification of the annular space integrity, including cementation, purging and treating of the heat exchanger, filling in and sealing the probe, conserving the location of the exchanger filled by an appropriate marking and covering the drilling head with inert waterproof clay-type material. For the OLS, the measures required at the end of exploitation include verification of the annular space integrity, including cementation, sealing the borehole with a waterproof plug of a mixture of swelling clays and cement, conserving the location of the exchanger filled by an appropriate marking.

Other common issues reported by respondents are:

- Conducting works by qualified companies is an important element, often mentioned in the guidance (Austria, Belgium, Denmark and the United Kingdom);
- The decommissioned wells might be refitted for the purpose of monitoring, this option is mentioned for Denmark and the United Kingdom in the recommendations for decommissioning of redundant boreholes;
- Notification and reporting to public authority are mentioned for Austria, Belgium and Denmark;
- It is obligatory to inform GSO about decommissioning borehole(s) in Denmark and the United Kingdom.

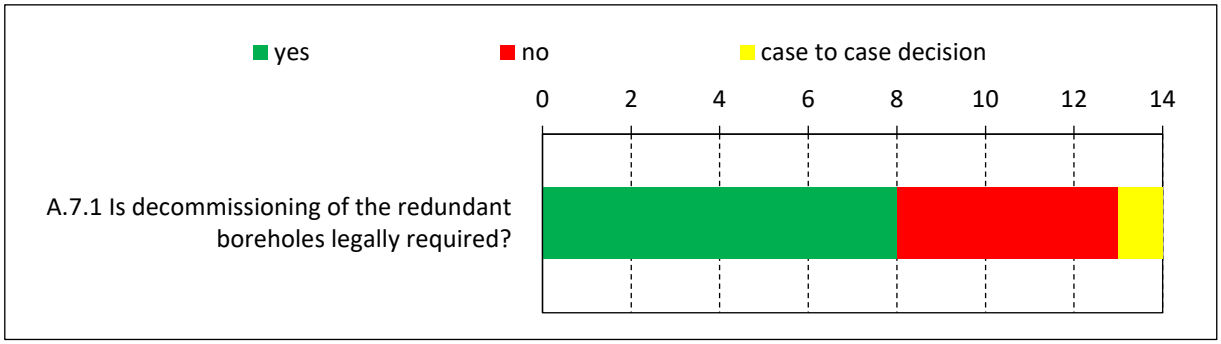


Fig. 15 Summary of partners' feedback on decommissioning of the redundant boreholes used for SGES

Tab. 13 Characteristics of decommissioning of boreholes used for SGES

PP	Country	Comments
P01	AT	Decommissioning is obligatory and the criteria are legally regulated The boreholes are decommissioned by certified staff
P02	UK	Decommissioning is not required however the good practices are made available by the Environmental Agencies
P04	HR	Decommissioning is not required however the unused boreholes are decommissioned by certified staff
P05	CZ	Decommissioning is not required however the unused boreholes are decommissioned
P06	FR	Decommissioning is obligatory and the criteria are legally regulated
P07	IE	Decommissioning is not required
P08	BE	Decommissioning is obligatory and the criteria are legally regulated
P09	SI	Decommissioning is obligatory and the criteria are legally regulated
P10	ES	Decommissioning is regulated by the Water Act The Mining Act enforces the re-establishment of natural conditions No specific regulations on SGES abandonment is predicted
P11	SE	Decommissioning is not required
P12	NL	Decommissioning and/or cleaning activities falls within the owner's responsibilities
P13	PL	Decommissioning of a borehole is required for all borehole abandonments, including OLS No specific regulations on borehole abandonment for SGES boreholes No special requirements/ recommendations predicted for CLS abandonment
P14	SK	Decommissioning of a borehole is required for all borehole abandonments, including OLS No specific regulations on borehole abandonment for SGES boreholes No special requirements/ recommendations predicted for CLS abandonment
P16	DK	Decommissioning can be demanded by municipality Required and voluntary decommissioning must be reported to the municipality and to GEUS Done by trained staff only

8.10 Monitoring of SGES

SGES monitoring comprises long-term activities referring to observations of operation and efficiency of the system and its possible impact on the natural environment. Sometimes observation of the

drilling process, including assurance of the quality standards, is regarded as part of the environmental monitoring, however these activities are constrained to a short the entire operation time.

Monitoring of system efficiency is performed by regular, discrete of continuous, measurements with the appropriate sensors of parameters such as operating hours, electricity consumption, groundwater extraction and injection volume, water temperature (for production well), heating and/or cooling medium temperature, thermal energy production, etc. Environmental monitoring of SGES installation focuses on any impact of the installation on all compartments of the environment. It is performed with help of regular measurements and control of the diverse environmental parameters and indicators, including groundwater level, temperature, physiochemical parameters of groundwater, chemical composition of groundwater, contamination of groundwater, rocks and soils, underground temperature, microbiota in groundwater and soils, etc. The procedures cover also physical inspection of the technical status of installation, with special respect to any malfunctioning, e.g. installation tightness and accidental leakages, circuit pressure, overexploitation, etc.

The results of the questionnaire reveal that monitoring of SGES is neither legally required nor commonly applied in majority of the project partner countries. Mandatory monitoring, regulated by legal acts, was reported for four countries only, namely Belgium, Denmark, France and the Netherlands. In some cases, the decision on implementation of SGES monitoring is up to regional regulations or it is taken for each installation individually, i.e. Austria and Spain. A summary of the replies to the questionnaire, part A, closed question no. 8. Monitoring of SGES is shown in Fig. 16, while Tab. 14 provides the short characteristics.

The methods for obligatory SGES monitoring differ considerably in four reported countries in terms of the scope of parameters and reporting manner. In France, which seems to have the strictest rules, for both systems it is compulsory to self-monitor the installation with a yearly report including the used production rate and the inlet and outlet temperatures for systems with an abstraction rate higher than 100.000 m^3/yr. For CLS, monitoring covers also the minimum temperature at the outlet of BHE, while for OLS the maximum temperature leaving the geothermal heat exchanger and the groundwater volumes withdrawn and rejected per annum. Under the terms of SGES monitoring, the operator of the installation is required to verify the proper functioning of the reinjection well, ensure the tightness of the primary network and balance the withdrawn and re-injected water.

In Belgium, SGES monitoring is mandatory for OLS, as described below. In addition, for the installations extracting more than 30 000 (m^3/year) the automatic recording of temperature is obligatory. Monitoring should be conducted in the 3 years reporting periods, on the time basis and in units appropriate for the individual parameters. Monitoring comprises the total groundwater flow supplying the heat pump, the peak power produced for heat and/or cold; average COP and the amount of heat extracted or injected into the underground per month, separately for cooling and DHW, average temperature of the probes, percentage of the hot/cold demand covered by geothermal energy and the electric energy consumed by the various components of the geothermal system.

In the Netherlands, monitoring of basic SGES parameters is required, however due to relatively high costs it is not commonly applied in practice. In Denmark, monitoring of groundwater temperature is required for ATES plants. For other installations monitoring of groundwater level can be sometimes required.

In some countries monitoring is not compulsory, though the appropriate recommendations and/or best practices are applied for OLS, due to the direct use of groundwater, such as:

- general monitoring of the groundwater bodies, as defined by the WFD;
- monitoring for OLS required by legislation on water protection, e.g. Slovakia, Slovenia and Spain;
- monitoring based on requirements stated in permission/license to operate;
- monitoring for tracking system's efficiency and heat recovery, e.g. Croatia and the United Kingdom.

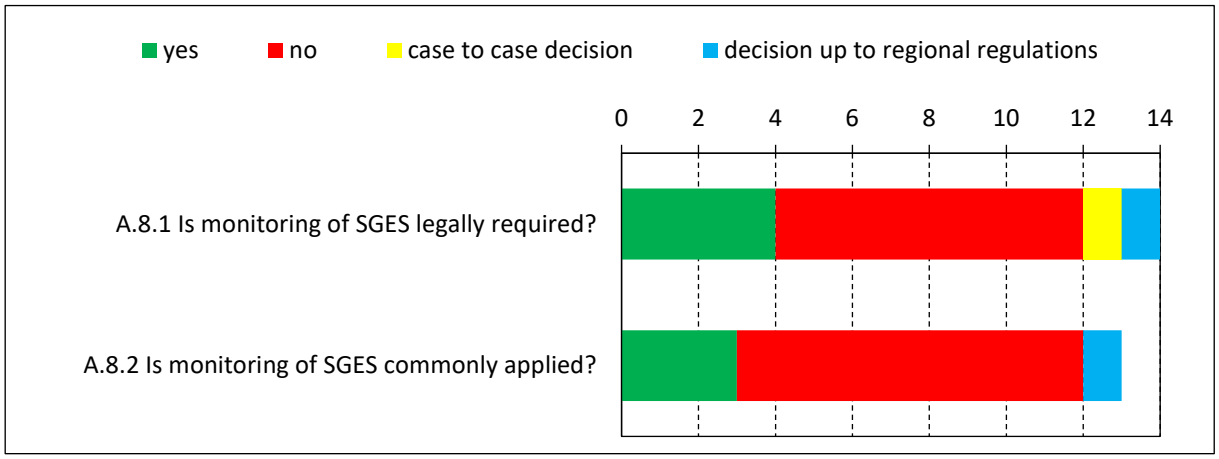


Fig. 16 Summary of partners' feedback on monitoring of SGES

More precision of diverse aspects of SGES monitoring was provided by the results of part E of the questionnaire which are illustrated in Fig. 17 and Fig. 18. In majority of the examined countries, monitoring is not enforced by the authorities. In some countries, e.g. Belgium and Spain, monitoring is mandatory for larger installations only. In Belgium, monitoring is applied to all OLS installations for water volume control, while temperature is monitored for reinjection well showing more than 30 000 m^3/year. In Austria, in the regions with complex hydrogeological conditions, monitoring is compulsory for all OLS installations. Apart of such regions, monitoring is mostly limited to large scale installations showing installed capacity of >30 kW. In Spain, no capacity threshold is given. In Denmark, no capacity limit in the legislation related to monitoring is provided either, however the individual permits can be specified based on case to case analysis. In Slovakia, monitoring is bound to the groundwater regulation.

With respect to efficiency of SGE installations, the recommendations on monitoring are made available in Denmark and France as well as in Austria and Czech Republic, respectively on the national and regional level. In Austria, those refer to the city of Vienna and in Czech Republic to the wells in OLS in the selected regions. GEUS in Denmark cooperated in preparation of the recommendations. The following parameters are the most commonly monitored for efficiency of SGE installations: volumes and temperature of extracted and injected water. Sometimes thermal energy production is also monitored.

The recommendations on environmental monitoring of SGES installations are available in Austria, Belgium, France, the Netherlands, Slovenia and the United Kingdom and in some cases in Denmark, Ireland and Sweden (Fig. 18). Environmental monitoring is officially required in Belgium, Denmark,

France, the Netherlands and the United Kingdom. The reported GSOs are usually not involved in environmental monitoring of SGE installations, except for GBA in Austria and in the selected cases: NERC BGS in the United Kingdom, HGI-CGS in Croatia, GeoZS in Slovenia, SGU in Sweden, PIG-PIB in Poland and GEUS in Denmark. The most often monitored parameters are groundwater head, groundwater temperature and in some countries physiochemical parameters and chemical composition of groundwater (e.g. Austria, Croatia, Spain and the Netherlands).

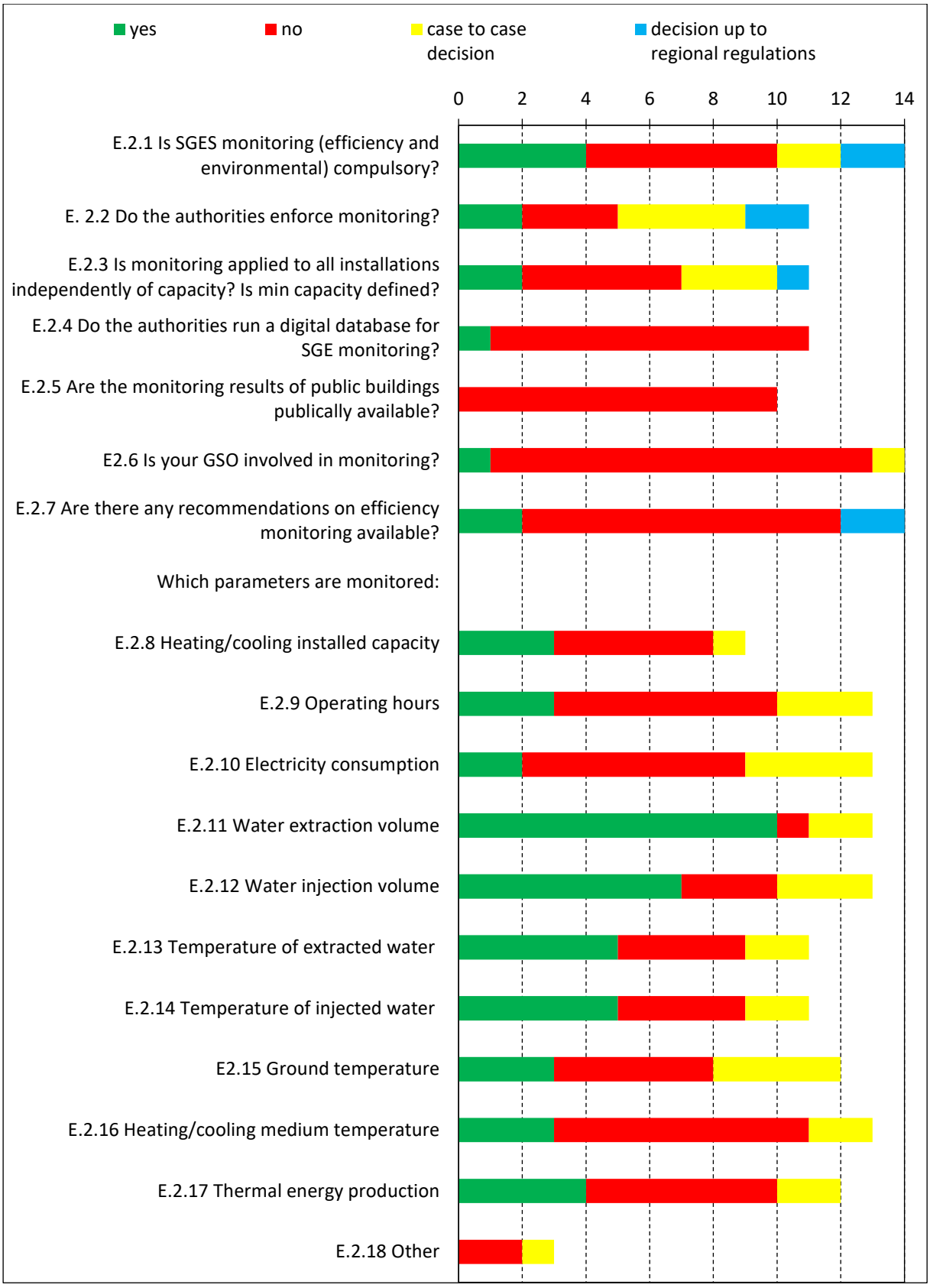


Fig. 17 Summary of partners' feedback on efficiency and environmental monitoring of SGES

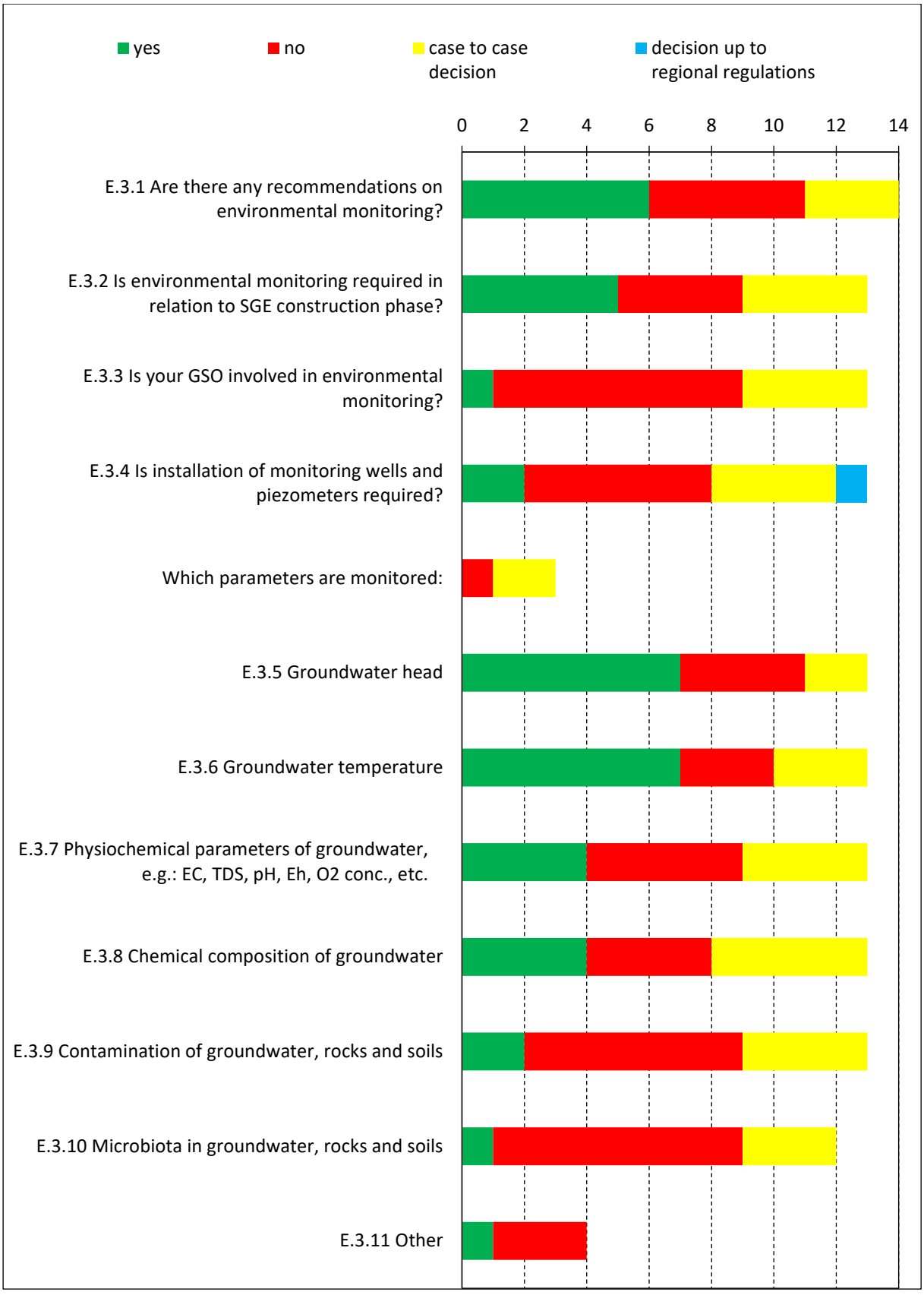


Fig. 18 Summary of partners' feedback on environment monitoring of SGES

Tab. 14 Characteristics of SGES monitoring and its key criteria

PP	Country	Drilling observations	SGES efficiency	Environmental impact	CLS	OLS	Comments
P01	AT	Obligatory post drilling tightness tests	On voluntary basis	Recommended	On voluntary basis	Case to case decision	GBA is involved in obligatory monitoring of groundwater temperature linked to a large scale OLS installations in Vienna Operational monitoring data can be demanded for large units (>30 kW) in Vienna In other regions, monitoring is mandatory for all installations in area of sensitive groundwater bodies
P02	UK		On demand in case of applying for Renewable Heat Incentive				
P04	HR		On voluntary basis for large scale units				
P05	CZ					Obligatory	Monitoring conditions provided by water permit cover dynamics and physiochemical status of groundwater
P06	FR				Obligatory	Obligatory	Extensive monitoring requirements including a number of parameters are imposed by legal regulations
P07	IE						
P08	BE					Obligatory	Extensive monitoring requirements including a number of parameters are imposed by legal regulations
P09	SI					Obligatory	Monitoring conditions provided by water permit cover dynamics and physiochemical status of groundwater

PP	Country	Drilling observations	SGES efficiency	Environmental impact	CLS	OLS	Comments
P10	ES					Obligatory for Zaragoza City	Water T at extraction and injection, pumping rates Reporting on demand of authorities in case of accidental situation
P11	SE						
P12	NL						Minimum requirements are being fulfilled
P13	PL	Obligatory Recommended post drilling tightness tests		Obligatory / Recommended			Monitoring conditions provided by water permit cover dynamics and physiochemical status of groundwater
P14	SK			Obligatory			Monitoring conditions provided by water permit cover dynamics and physiochemical status of groundwater
P16	DK						T monitoring required for ATES Groundwater table depth required optionally

8.11 Review of the flowcharts for licensing procedures in the project partner countries and pilot areas

This subchapter discusses the main features of the flowcharts illustrating licensing procedures which were collected all together from 11 project partners. Due to lack of binding regulations or their complex character, preparation of the flowcharts was not possible for 2 countries. The flowcharts are presented in the **Appendix II** Portfolio of the flowcharts, the partners' questionnaire, part B *Flowcharts for licensing procedures in the pilot areas*.

The flowcharts prove strong heterogeneity of procedures from rather detailed, like in case of France and to some extent in Slovenia, to uncomplicated and straightforward patterns, like in case of Croatia or Sweden. No requirements at all for the permission for both CLS and OLS have been reported only for Ireland. The reported procedures strive to establish the operations adequate for legitimate protection of the environment, especially groundwater and surface waters, as well as for decreasing possible influence of the planned installations on the existing ones. Ordinarily, due to EU regulations on the direct use of water, the permitting regulations for operation of the OLS and GWHP installations have been developed (to diverse extent) and reported for all respondent's countries, except for Ireland.

Compared to the requirements patterns for OLS, the procedures for the CLS and the GSHP installations are often simplified and reduced to the activities connected with assessment of impact on groundwater and/or other already existing installations, e.g. in Croatia, the Netherlands, Sweden, or do not exist at all, e.g. in the United Kingdom.

Commonly, the major regulatory bodies involved in the procedures of granting the permissions and/or licences are the environmental and water agencies, municipalities and in one case i.e. Slovakia the Ministry of the Environment (MoE). The role of the GSOs in the administration procedures is limited to advisory duties and archiving borehole data. SGU (Sweden) reported archiving the results of investigations (drilling) for both CLS and OLS in a borehole register, while PIG-PIB (Poland) reported its advisory role, on request only, which can take place at any point of the SGES installation as well as archiving of documents and processing of data within the databases.

Often, the reported factors conditioning the permission and/or licensing procedures are depth of installation, yield of the extraction well(s), water reinjection rate and power capacity of the planned installations, e.g. France, Poland, Slovakia and Slovenia. It is worth noticing that in case of the city of Vienna a geothermal map has been reported as a tool used in the permitting procedures. Therefore, mapping of geothermal potential and possible environmental and anthropogenic conflicts, as pursued in the framework of MUSE, GeoPLASMA-CE or other projects, leads into development of meaningful and effective mechanisms which could be applied in planning and development of SGES.

8.12 Review of specific geological and geographic conditions limiting SGES

Feedback to the part C of the questionnaire was provided by 14 partners. Its general overview and descriptive statistics are presented in the Appendix III Review of the closed questions of the partners' questionnaire, part C *Specific geological and geographic conditions which can limit SGES*, and in Fig. 19, while main features of the provided replies and comments by the partners are discussed here below.

Part C of the questionnaire consists of specification of the geological and geographic conditions under which the SGES, both CLS and OLS, would be allowed. A significant number of those refer to groundwater and hydrogeological conditions as one of the most decisive factors in terms of the SGES operation. As the partner replies reveal, the CLS and OLS are often allowed, under the following conditions:

- artesian and confined aquifers;
- shallow unconfined aquifers into which reinjection can be problematic;
- perched aquifers;
- multi-layered aquifer systems.

It should be emphasized that for several reported countries under the above conditions the decisions on SGES installation are based on the results of analysis of each particular case (case to case decision). The possible restrictions related to hydrogeological conditions are in many cases based on water protection regulations. Usually, SGES are limited under two conditions:

- contaminated soils and groundwater;
- water protection areas.

Regarding the water protection areas, construction of SGE installations is prohibited in the inner protection zones of groundwater and drinking water intakes, e.g. in Austria, Croatia, France and Poland and Croatia, while in the outer zones other limitations occur. Often, the *case to case decision* comes along with the decisive competences of the local and/or regional authorities, i.e. bodies in charge of water and environment including the water management plans, e.g. in France, Slovakia and Spain. The installations must be generally compatible with the local spatial planning and development plans and fulfil their requirements, e.g. in Czech Republic and Ireland. Depending on the local conditions, as regards to *case to case decisions*, sometimes expert's evaluation of an SGE project is required, e.g. in Czech Republic.

Special restrictions on SGES are encountered under the conditions referring to nature protection areas, where normally each installation must be approved by the authority in charge.

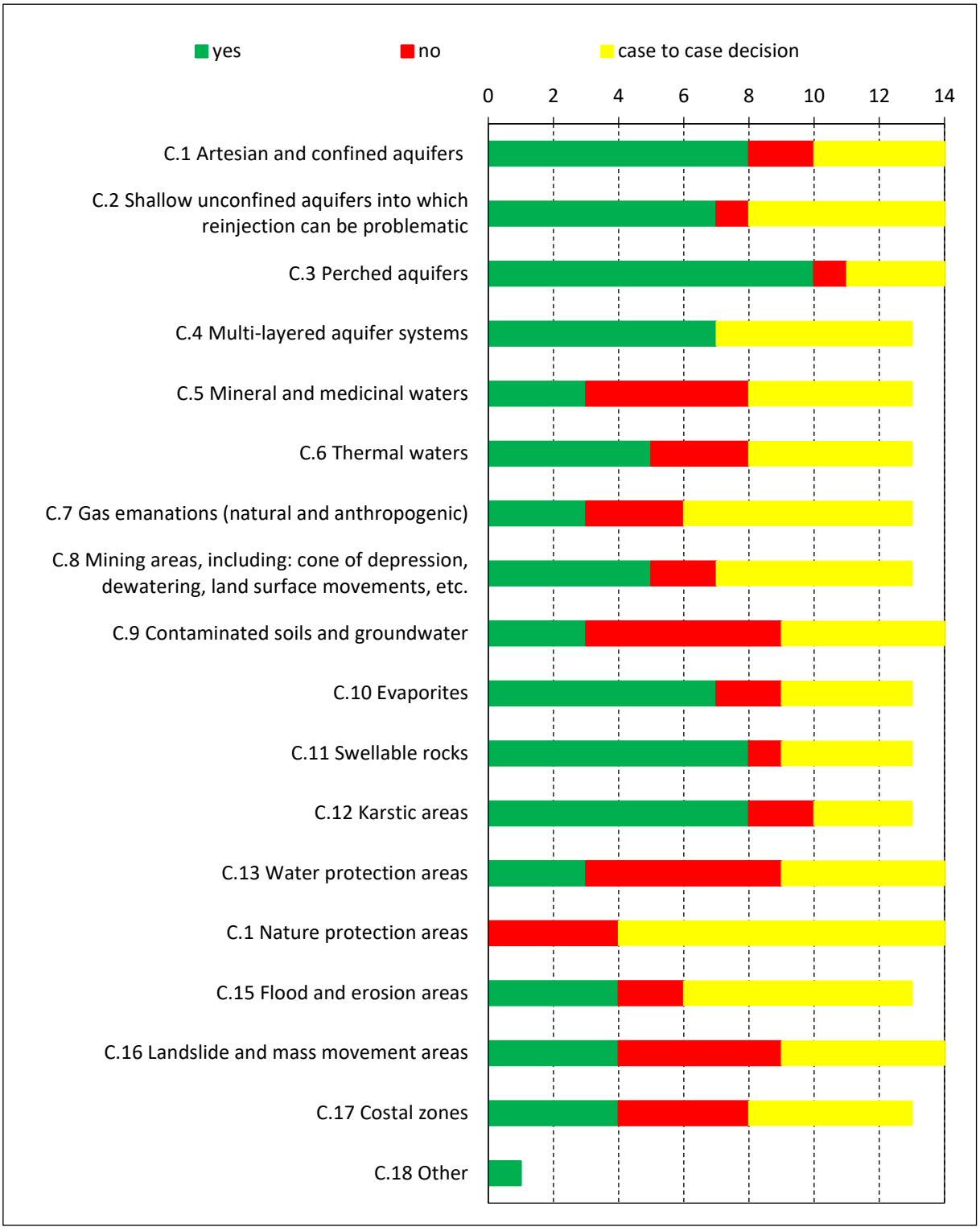


Fig. 19 Summary of partners' feedback on specific geological and geographic conditions limiting CLS and OLS

8.13 Review of regulation elements for the installation, implementation and operation of shallow geothermal energy systems

All together 14 project partners provided the feedback to the part D of the questionnaire. Part D of the questionnaire consists of specification of the regulation elements referring to SGES, as presented in Tab. 4 and Appendix IV. The general overview of partner replies and descriptive statistics are presented in the Appendix IV Review of the closed questions of the partners' questionnaire, part D *Regulation elements for the installation, implementation and operation of shallow geothermal energy systems*, while the main features of the provided replies and comments by the partners are discussed here below and illustrated by the Fig. 20, Fig. 23 and Fig. 24.

For both CLS and OLS, drilling below the groundwater table is allowed, however it must be assessed based on analysis of each individual investment (*case to case decision*) and often depends on the decision of the local water authority in the drinking water shortage areas. In many cases certification of designers, planners and installers of SGES is not mandatory, however certification or some authorisation of the drillers is available in, e.g. Austria, Belgium, Czech Republic, France, Poland and Slovakia. In Austria, the training courses supporting certification with focus on installation of BHE are provided by the federation of drillers.

Numerical models and simulation studies assisting the SGES installation design are required in some countries, especially in case of large scale investments and possible interference with existing installations (Austria capacity > 10 to 30 kW, the United Kingdom), OLS (Belgium) and ATES (Denmark) installations.

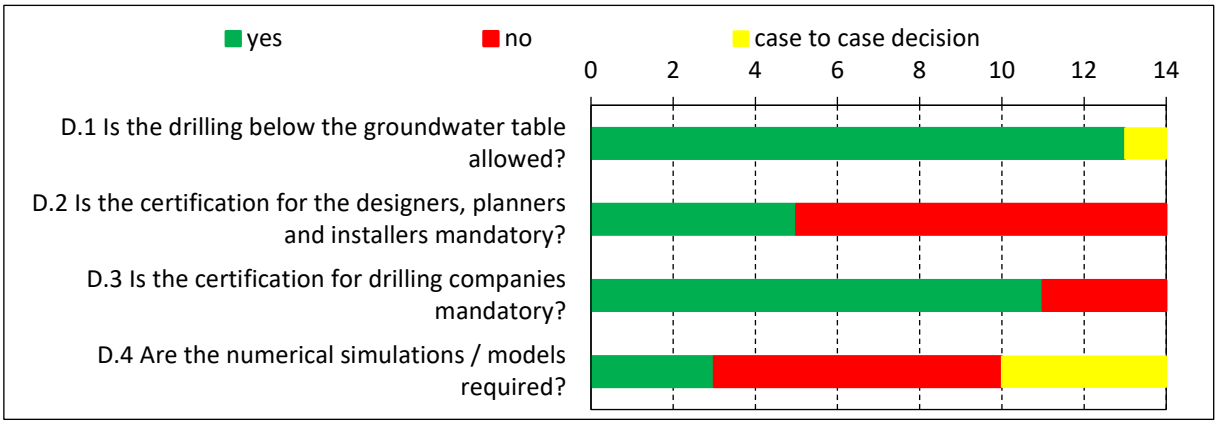


Fig. 20 Summary of partners' feedback on regulation elements for installation, implementation and operation common for CLS and OLS

Further specific regulations on OLS (Fig. 21) refer to minimum distances to neighbouring ground plots, buildings and groundwater wells and boreholes for CLS. Those, in most cases are not legally defined either the decision is taken based on case to case analysis. Nonetheless, in a number of countries the legal regulations and professional guidelines provide some rules and protocols, e.g. in Austria, Belgium, France, Poland and Slovenia. The details are given in Fig. 21 and Tab. 15 for OLS as well as in Fig. 22 and Tab. 16 for CLS.

The reinjection of used groundwater via the injection wells is allowed in almost all respondent's countries, with an exception of Denmark. Reinjection however requires granting the water discharge permit, e.g. in France, Poland Slovakia, and the United Kingdom, under the condition that all water volume produced must be re-injected (France) and cooled down (Czech Republic).

The regulations related to groundwater temperature are usually not obligatory or depend on each individual installation (*case to case decision*), with some exceptions, eg. Austria, the United Kingdom. Again the values differ very much between the countries. In some regions of Spain, the rules referring to water temperature are defined by the river basin management plans. The details on applicable maximum allowed temperature differences, temperature ranges and changes for OLS are provided in Tab. 17.

The groundwater investigations including water dynamics, chemistry and pumping tests are obligatory or at least recommended in majority of the responding countries. Sometimes those depend on the local conditions of the individual installations (*case to case decision*). Repeatedly, e.g. in Austria, those are required for the large scale units, however no allowed groundwater drawdown for the GWHP installations is normally defined.

The specific regulations on CLS (Fig. 22) seem to be less strict compared to OLS, the most probably due to lack of binding EU regulations. The minimum distances to the neighbouring ground plots, buildings, groundwater wells, BHE are legally defined and/or recommended only in case of Austria, Denmark, France, Poland, Slovenia and Spain (Fig. 22, Tab. 16). The regulation elements referring to temperature of the heat carrier fluid are vastly not defined. In case of France, the temperature of the heat transfer fluid which returns to the closed geothermal heat exchangers must be between -3 and 40^{o}C. In Austria, the mean temperature of the heat carrier fluid (average of mean inlet and mean outlet temperature of BHE) must not fall below -1.5°C or exceed 30°C.

The types of heat carrier fluid and the refrigerant are in several countries regulated. Type of grouting is also regulated only in some countries. Other activities connected with installation of CLS and BHE, such as TRT, exact measurement of the borehole depth and groundwater investigations are not mandatory, while the tightness test of the CLS and refrigerant tubing borehole drilling report are required in majority of the respondent's countries.

Tab. 15 Regulation elements applicable for OLS installations referring to minimum allowed distances in the selected countries

Country code	AT	UK	FR	BE	SI	PL
Closed questions Partner questionnaire, part D						
Q D.5 Is the minimum distance (m) to the neighbouring ground plot defined?	3				2	5
Q D.7 Is the minimum distance (m) to the neighbouring groundwater wells defined?		200	35	10		
Q D.8 Is the minimum distance (m) between the wells defined?		50		10		
Q D.9 Is the minimum distance (m) between the pumping and reinjection wells defined?		50			25	

Tab. 16 Regulation elements applicable for CLS installations referring to minimum allowed distances in the selected countries

Country code	AT	FR	SI	ES	PL	DK
Closed questions Partner questionnaire, part D						
Q D.5 Is the minimum distance (m) to the neighbouring ground plot defined?	3	5	2		3	
Q D.7 Is the minimum distance (m) to the neighbouring groundwater wells defined?		5			2	
Q D.8 Is the minimum distance (m) between the wells defined?						50
Q D.9 Is the minimum distance (m) between the pumping and reinjection wells defined?	8			6	6	

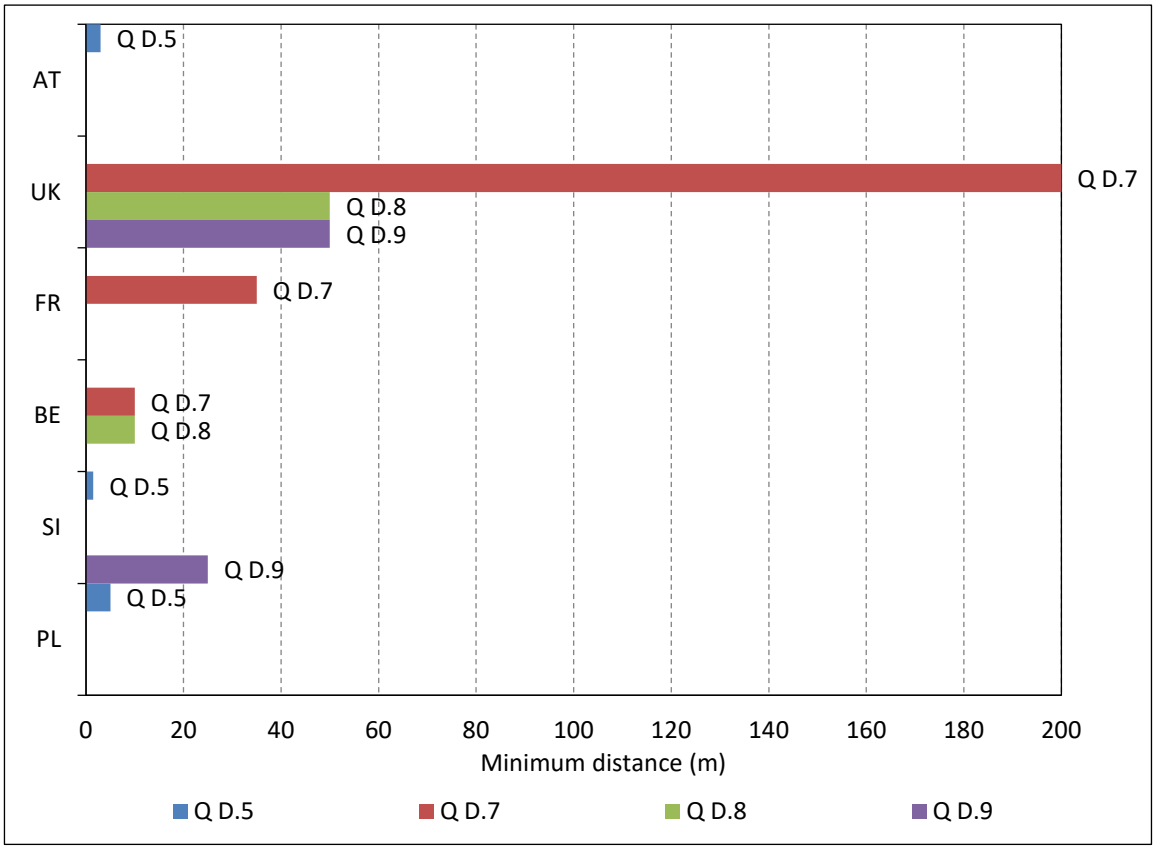


Fig. 21 Summary of partners' feedback on regulation elements referring to minimum allowed distances applicable for OLS installations in the selected countries

Comments to Fig. 21:

Q D.5 Is the minimum distance (m) to the neighbouring ground plot defined?

SI: if L < 1.5 (m) written consent of neighbouring land owners is required
PL: distance could be smaller, if accepted by the owner of the neighbouring ground plot

Q D.6 Is the minimum distance (m) to the neighbouring buildings defined?

AT: neighbouring ground plot boarder
SI: agreement of the competent body responsible for the waterworks, sewage systems, transport, heating networks, telecommunications, etc. is required

Q D.7 Is the minimum distance (m) to the neighbouring groundwater wells defined?

UK: 200 (m) between open loop systems
FR: only if the neighbouring groundwater well is used for human consumption, if a protection perimeter is defined it will apply, else the distance is 35 meters. 3 perimeters are defined: immediate, close and distant. Geothermal operations are not possible in immediate and close protection perimeters of wells used for drinking water supply
BE: min 10 (m) can be up to 30 (m) if justified
ES: defined by the Water Act

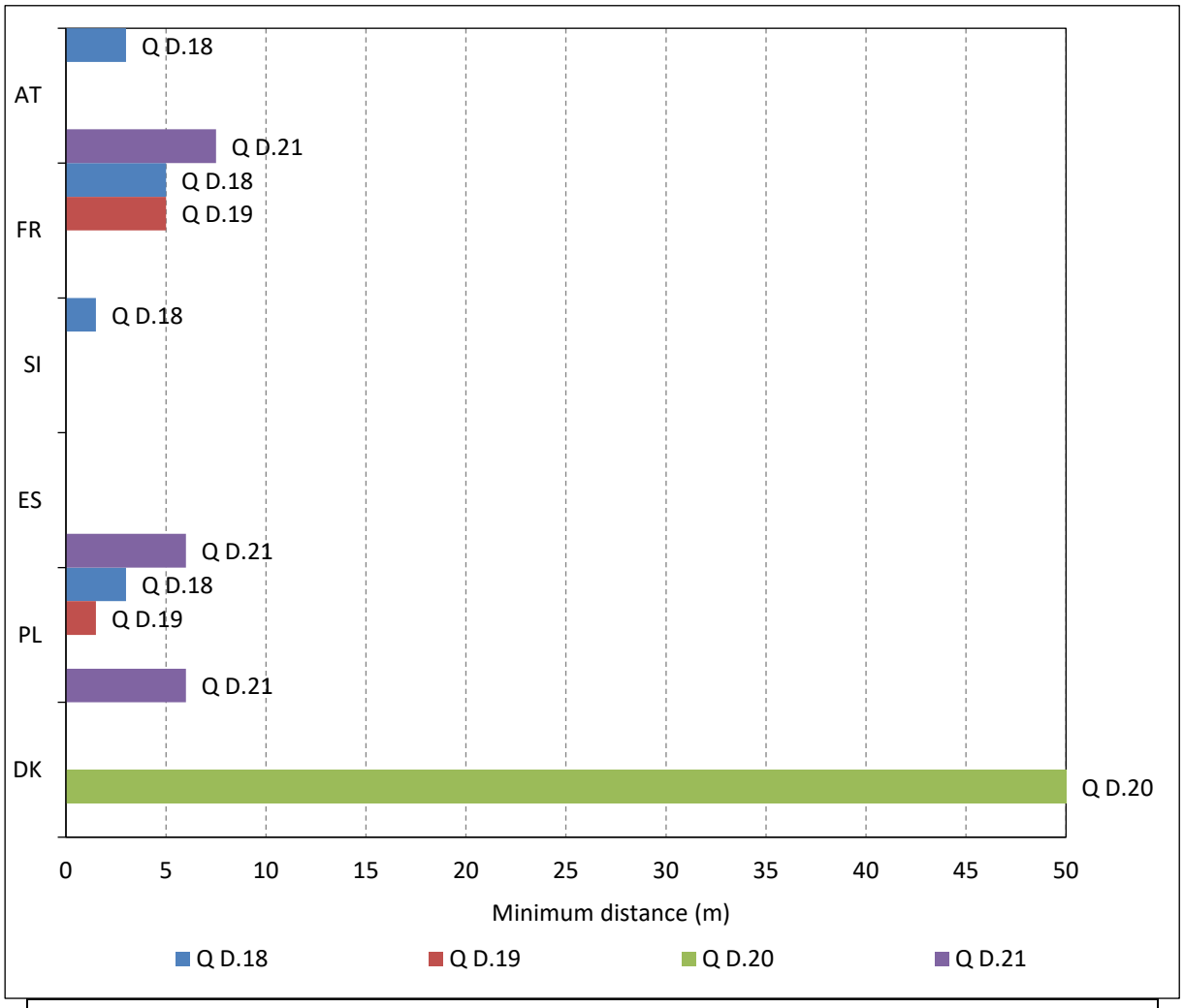
Q D.8 Is the minimum distance (m) between the wells defined?

BE: min 10 (m) can be up to 30 (m) if justified
SI: agreement of the competent body responsible for the waterworks, sewage systems, transport, heating networks, telecommunications, etc. is required

Q D.9: Is the minimum distance (m) between the pumping and reinjection wells defined?

BE: a technical note assessing the impacts over 20 years of the geothermal system on local hydrodynamic conditions, the stability of neighbouring constructions, as well as on the temperature of the basement has to be provided
SI: L ≥ 25 (m), extraction well upstream of the injection well which is defined by Mining Act

Q D.10: Is the minimum distance (m) to the neighbouring closed loop systems defined?



BE: a technical note assessing the impacts over 20 years of the geothermal system on local hydrodynamic conditions, the stability of neighbouring constructions, as well as on the temperature of the basement has to be provided

Fig. 22 Summary of partners' feedback on regulation elements referring to minimum allowed distances applicable for CLS installations in the selected countries

Comments to Fig. 22:

Q D.18 Is the minimum distance (m) to the neighbouring ground plot defined?

SI: if L < 1.5 m: written consent of neighbouring land owners
ES: 3 (m) is recommended by Spanish UNE-ISO norms UNE 100715-1:2014

Q D.19 Is the minimum distance (m) to the neighbouring buildings defined?

AT: neighbouring ground plot boarder
SI: agreement of the competent body responsible for the waterworks, sewage systems, transport, heating networks, telecommunications, etc. is required

Q D.20 Is the minimum distance (m) to the neighbouring groundwater wells defined?

FR: only if the neighbouring groundwater well is used for human consumption. If a protection perimeter is defined it will apply, else the distance is 35 (m). 3 perimeters are defined: immediate, close and distant. Geothermal operations are not possible in immediate and close protection perimeters and are controlled or require authorisation in the distant perimeters of wells used for drinking water supply
PL: within the areas of direct protection of water intakes it is forbidden to locate any objects which interfere with the hydrogeological settings. In indirect water protection zones it may be limited
DK: 50 (m) to private well and 300 (m) to waterworks wells

Q D.21 Is the minimum distance (m, % of well depth) between the borehole heat exchangers defined?

ES: 6 (m) is only recommended by Spanish UNE-ISO norms UNE 100715-1:2014 PL: 6 (m) or 8% of BHE depth

Tab. 17 Regulation elements for OLS referring to water temperature applicable in the selected countries

Country code	AT	UK	FR	BE	ES	DK
Closed questions Partner questionnaire, part D						
D.12 Is the maximum allowed temperature difference (°C, K) between extracted and reinjected water defined?	5°C - 6 °C	8 °C in England			±6 to ±8 °C defined by river basin management plans	
D.13 Is the absolute allowed temperature range (°C, K) of the reinjected water defined?	5-20 °C recommended: 5-20 °C Pilot area Vienna: 5-18 °C		must not exceed 32 °C	4-25 °C	30 °C defined by river basin management plans	25 °C peak value 20 °C monthly average
D.14 Is the allowed temperature change (°C, K) defined?	5°C - 6 °C	8 °C	must not cause temperature variation of exploited groundwater of more than 4 °C at 200 (m) from the geothermal heat exchangers for production or reinjection			

Fig. 23 Summary of partners' feedback on regulation elements for installation, implementation and operation specific for OLS

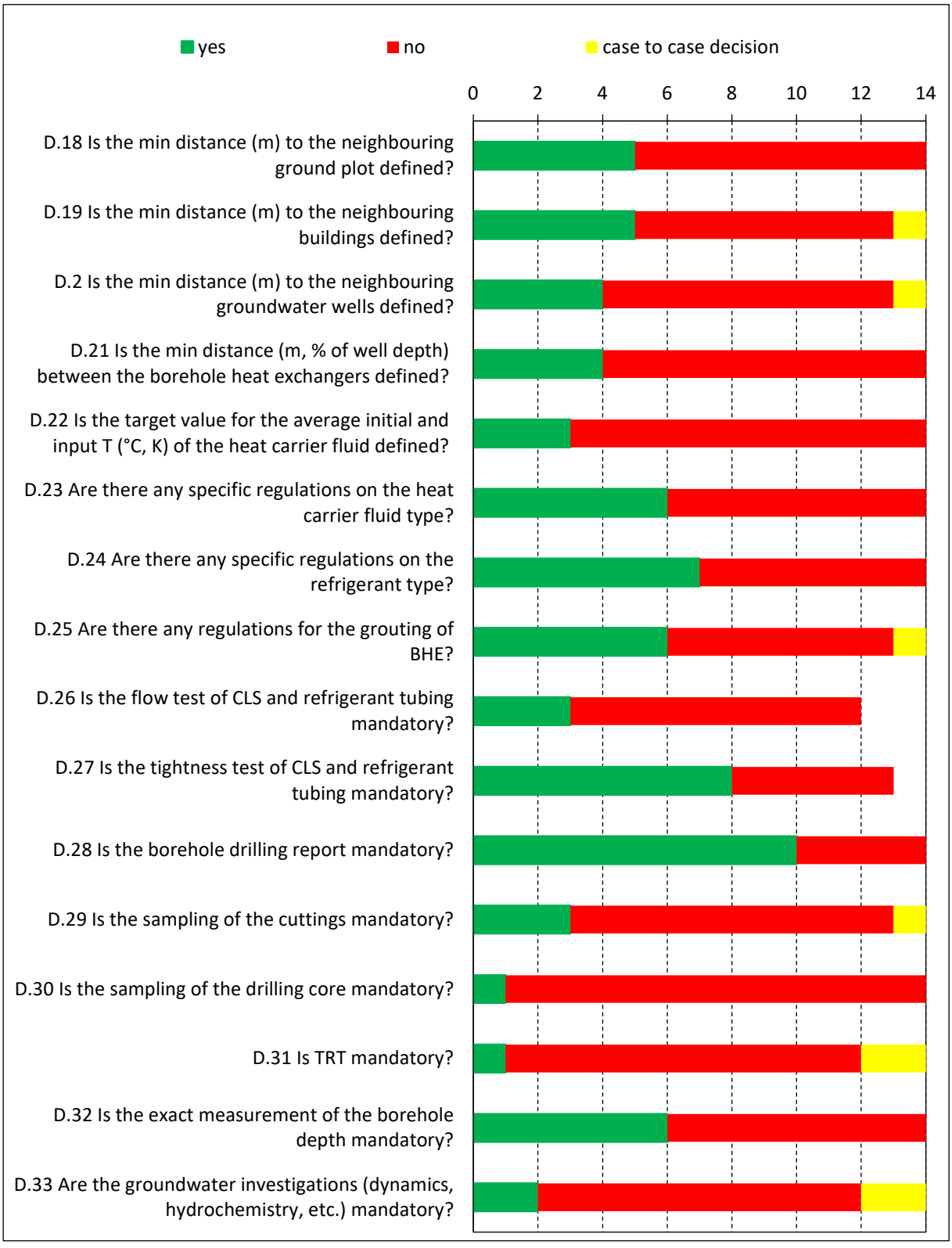


Fig. 24 Summary of partners' feedback on regulation elements for installation, implementation and operation specific for CLS

9 IDENTIFICATION OF BARRIERS AND RECOMMENDATIONS ON SGE MANAGEMENT

The EU projects, such as ReGeoCities (Pasquali, O'Neil 2015) and GeoPLASMA-CE (Rupprecht et al. 2018; Goetzl et al. 2019; Rupprecht et al. 2019) have studied and discussed existing recommendations for SGE use and its management. They also proposed incentive measures including better technical standards and improvement of the administrative procedures aiming at fostering the development of SGES

The activities pursued within the framework of MUSE build upon the achievements of the previous studies. MUSE identifies barriers, gaps and deficiencies in context of SGE legal management and administrative regulations for fourteen project partner countries and recommends solutions.

Barriers and recommendations: lack of common SGE definition

There is a common understanding of SGE concept and of activities pursued as the SGES, however among all researched countries SGE is legally defined on the national level only in Croatia and France, while in Belgium, the definition exists on the regional level (Tab. 8). Defining SGE will provide legal certainty (Rupprecht et al. 2018) and will contribute to simplification of the procedures and regulations linked to SGE management which in effect will foster development of the market and technologies. A common SGE definition relying on the depth and/or underground temperature concepts, as well as other technical aspects when needed, distinguishing between the existing types of installations, such as CLS, OLS, ATES, BTES, horizontal collectors, etc., should be elaborated and implemented on the EU level. Nevertheless, the most crucial is a proper recognition of SGE by legal regulations on both EU and national levels.

<u>Common SGE definition proposed by the MUSE project:</u>

Alternative 1

Shallow geothermal energy (SGE) is a renewable energy source (RES) stored in the form of heat beneath the surface of solid earth. SGE is a compartment of ambient energy – naturally occurring thermal energy accumulated in the environment with constrained boundaries. SGE could be conditioned by depth, up to between 200 and 500 metres b.g.l. and/or underground temperature below 30 ^{o}C. According to the available temperature levels shallow geothermal energy can be listed under the ambient thermal energy systems, such as aerothermal and hydrothermal (surface water use).

Alternative 2

Shallow geothermal energy (SGE) is a renewable energy stored in the form of heat beneath the Earth surface. SGE is a naturally occurring thermal energy accumulated and in a continuous flow according to the thermal gradient in a compartment of the subsurface with constrained boundaries. SGE reservoir in most cases is limited by underground temperature of up to 20-30^{o}C and depth up to 200 - 500 metres b.g.l. according to local conditions. According to the available temperature levels shallow geothermal energy can be listed under the ambient thermal energy systems, such as aerothermal and hydrothermal (surface water use).

Barriers and recommendations: imprecise and non-regulated ownership and access rights to SGE resources

The ownership and the access rights to the SGE resources are insufficiently defined in several of the investigated countries for both CLS and OLS (Tab. 11 and Tab. 12, respectively). This situation is not favourable from the point of view of the investor therefore the long-term rights on thermal exploitation conditions should be clearly stated in the licensed permit. At present, the rule *first come, first served* is commonly applied in numerous countries which to a large extent is far from being an optimal solution. This current permission policy seems to be rather an effect of lack of SGE resources management and causes exclusion of any further users in future. SGE licensing should be conditioned by the results of studies on admissible capacity of GSHP and GWHP on local and regional (city) scale. The natural conditions and licensing terms should be included in GIS based city planning and management. The GSOs could be a part of development and operation of SGE resources management and planning. The access rights to SGE resources must be clearly defined and included in the license for each SGES.

Barriers and recommendations: too complex legal framework

The legal framework referring to SGES is too complex and fragmented. SGE management, including applications for new installations, are often governed by the documents and regulations referring to several areas and aspects (Tab. 9). In case of Czech Republic, France, Slovenia, Spain and Poland, 5 or more legal regulation areas apply, with the maximum for Poland amounting up to 8 regulation areas. On the other hand, the appropriate legal regulations in the countries where thermal energy production depending on SGE is well established, i.e. Austria, Belgium and Sweden, apply to a relatively lesser number of regulation areas, i.e. between 1 and 3, respectively. In case of Sweden, which is one of the key SGE market in Europe (EGEC 2019) and shows the highest total capacity of the installed SGE units, the legal regulation is limited and the key document published (with several updates) by SGU (Normbrunn –16 2016) gathers the recommendations referring to well construction, geological and hydrogeological conditions and selected technical aspects.

There is an urgent need for simplification of legal regulations on SGE, especially for small scale units with capacities lower than 10 kW, e.g. single family homes. It is important for its sustainable and efficient use. The existing national laws could be reassembled in one fundamental document specialised on SGE and regulating implementation of CLS, OLS, ATES and BTES in a comprehensive way, like in case of Denmark, the Netherlands or Sweden. The non-binding technical standards and recommendations should be made available.

Fragmentation of legal requirements among several regulation areas triggers complex processing of SGES application. In order to shorten and simplify the administrative operations a one-stop-shop concept must be implemented.

Barriers and recommendations: convoluted and time consuming licensing procedures

Licensing of SGE installations is obligatory in majority of project partner countries. In general, application procedures are slightly simpler for CLS than for OLS (Tab. 11 and Tab. 12, respectively). Usually, the same regulations apply to all applicants, while simplifications for smaller scale

investments, like single family housing, are desirable. In several countries the length of application and granting the license is not legally regulated nor limited which might be a cause of lengthy administrative operations hampering investment progress and construction of SGES. Therefore, the length of licensing procedure, if required at all, must be shortened and set to acceptable minimum. As a rule all national licensing and permitting procedures should be adapted to comply with the measures requested by EU directive 2018/2001/EU.

Barriers and recommendations: insufficient measures for facilitation of SGE licensing procedures

Among the identified measures aimed to comply with the Article 15 of the RED II Directive (Directive 2018/2001) and facilitate the SGE licensing procedures the most common are those referring to administrative charges (*no application fee* and *no license fee*), timeframe (*max time limit to issue a licence* and *unlimited license length*) (Tab. 11 and Tab. 12).

The e-government concept and e-services, including the o*ne-stop-shop* and *online application* measures are still not employed to a sufficient degree. Implementation of measures connected with electronic means as well as use of possibilities provided by the Internet and electronic mail should be further developed and introduced. The applicants should be able to use the ready-made online templates instead of analogue paper documents. Those will allow for application from a distance, without submitting a paper version of application which is especially important nowadays during COVID-19 pandemic. Development of other significant facilitating measures of purely administrative nature, such as *one-stop-shop* and *self-starting permission* should not be neglected.

Barriers and recommendations: lack of comprehensive registers on shallow geothermal installations

In most European countries, actual registers do not show all installed SGE systems. The reason for this is, among others, unnecessary or optional licensing of SGE installations and/or, in case of obligatory licensing, the illegal constructions - without a license. Knowing the actual and full range of installed SGES, with regard to their location is a key for assessing the environmental impact, including thermal and hydraulic summation effects, as well as for identifying the market trends. Only with complex knowledge from properly designed register of installed SGE systems with suitable tools employed the sustainable resource management of shallow geothermal resources is possible.

For these reasons, properly designed, comprehensive and complete registers are required, which need to be accomplished with the following measures:

New systems: introducing the obligation to register an installation even in case when no license is needed. Electronic registers with an online input of key parameters such as location, type of installation and planned energy extraction or injection would facilitate the communication between operators and authorities.

Existing systems: contacting the neighbours in case of new system applications to motivate operators of existing, non-registered, installations to communicate the existing system to the authority. In case these neighbours respond, they could be involved into the licensing procedure to defend their interests.

Barriers and recommendations: non-regulated abandonment of the SGES boreholes

Decommissioning of abandoned OLS wells is regulated in majority of the project partner countries, however no official rules apply to CLS equipped with BHEs, as the technology is still new in many places. Uncontrolled decay of abandoned CLS may trigger groundwater leakage from different aquifers, ease the contact between ground surface and underground and in effect cause contamination of soils, aquifers and groundwater bodies. A professional standard environmental procedures and technical requirements for decommissioning of the boreholes must be elaborated and legally imposed on the owners of the installations in order to prevent accidental pollution from ground surface, groundwater leakage from unsealed aquifers and possible mixing of diverse groundwater types. All decommissioning activities must be completed by qualified and trained staff and their results must be reported to the appropriate authorities.

Barriers and recommendations: non-regulated SGES monitoring

SGES monitoring is usually neither legally required nor commonly applied on voluntary basis, however its results are crucial to control the quality of the environment and also the efficiency of the installation. Monitoring data will help to properly operate the installation and support spatial planning and development in larger scale, if gathered from several units. It should be kept in mind that monitoring is rather costly which effectively refrains the SGES operators from conducting it. A set of minimum acceptable parameters for operational efficiency and environmental monitoring, in case of both CLS and OLS should be elaborated and put into legal requirements. In order to minimize the monitoring costs the automated monitoring devices with data loggers or better data transmission possibility need to be used. A set of parameters for both operational efficiency and environmental monitoring need to be prepared, probably on regional scales at most, as they may depend on local conditions, to deliver reference for monitoring results and allow for efficient control based on them. Proper authorities must undertake a responsibility for management and control of SGES performance in their spatial territory based on collected monitoring results. The legal requirement of delivering such results to a proper authority needs to be a rule then. Conditions and standards for reporting the monitoring results to the authorities in charge must be elaborated.

Barriers and recommendations: limited access to knowledge, information and data on geographic and geological conditions influencing construction and operation of SGES

Special geographic and geological conditions influencing construction and further operation of SGE installations require a case-specific assessment and professional knowledge and expertise. Therefore, information about these special conditions and undertaken risk mitigation measures must be well described by the SGES license. The same applies for special attention areas of for example water and nature protection, where special precaution is requested. Moreover data about the subsurface gained during the application procedure (e.g. geological log, pumping test results, etc.) should feed into a modern information systems in terms of updated databases and updated interpreted maps.

10 RECOMMENDATIONS ON WORKFLOW FOR LIFESPAN OF SGES

A recommended workflow for the lifespan of SGES showing the major features (Fig. 25) was prepared based on flowcharts showing legal and administrative procedures applied to the SGES in the project partners' countries (Appendix II). In their workflows the partners also indicated other elements, facts and decisions referring to the entire scope of design of the system, legal regulations, administrative proceeding and conditions of operation of SGES in the project partners' countries. The resulting recommended workflow was partly adapted from work of Hähnlein et al. 2013 showing suggested legal framework for a sustainable use of shallow geothermal energy. The following major phases referring to diverse SGES types were identified:

- Type;
- Usage;
- Size;
- Technical assessment;
- Environmental assessment;
- Design report;
- Administrative proceeding;
- Construction;
- Registration;
- Operation and monitoring;
- Abandonment.

The first phases refer to analysis of available SGES technologies in term of present and planned energy demand. Those lead to a choice of SGES type to be applied and eventually constructed.

Thereafter assessment of the planned SGES takes place – namely the considered system is analysed taking into account diverse regulation elements, technical conditions and resulting constraints. These elements cover also geographic, geological and hydrogeological conditions (Appendix III and Appendix IV) – presence, diversity and structure of underground, including aquitards, aquicludes and aquifers. Depending on type of the chosen system, e.g. CLS, OLS, BTES or ATES, different features, such as thermal properties of soils and rocks and hydrogeological conditions, are considered in varying degrees. The project team suggests performing numerical modelling studies for complex and large-scale systems. Technical assessment is mainly focused on analysing possible influence of SGES on ambient temperature of underground, while environment assessment refer to potential influence on and threats to the environment, especially groundwater, soils and rocks.

The above phases result in preparation of the SGES design report submission of which to relevant administrative authorities starts the process of administrative proceeding. The report is first of all assessed in terms of compliance with legal regulations. Finally, an administrative decision on approval or rejection thus on SGES licensing and construction permit is made. The project team strongly suggests including in administrative proceeding all possible facilitation measures, such as e-government policy, possibility of online application, maximum time limits for administrative procedures facilitation, self-starting permitting, etc. (Tab. 10). In the same time all the barriers hindering development of SGES, such as: non-regulated ownership and access rights to SGE resources, too complex legal framework, convoluted and time consuming licensing procedures, lack of

comprehensive registers and limited access to knowledge, information and data on geographic and geological conditions, should be eliminated or at least maximally reduced. Special attention should be paid to facilitation of small-scale units including family housing. On the other hand, performance of TRT and other examinations could be applied to the complex and large-scale SGES for which licensing should be time limited with possibility of periodical renewal.

Constructed SGES should be registered with relevant authorities, while borehole data acquired during construction of SGES should feed geological data bases. Efficiency and environmental monitoring of operated SGES improves operation of the system and provide additional data. If the results of environmental monitoring prove any deterioration of the environment, especially groundwater, all measures should be undertaken in order to carry out efficient and successful remediation.

The operation of SGES should end with its proper abandonment including removal off all possible underground and ground-based infrastructure, especially heat carrier fluids, piping and tubing. All existing wells for OLS and boreholes for CLS must be well cemented preventing perforation of aquifers, especially artesian, resulting in mixing of diverse groundwater types. It also must stop possible migration of gases and other fluids along the borehole and migration of any contamination from the ground surface.

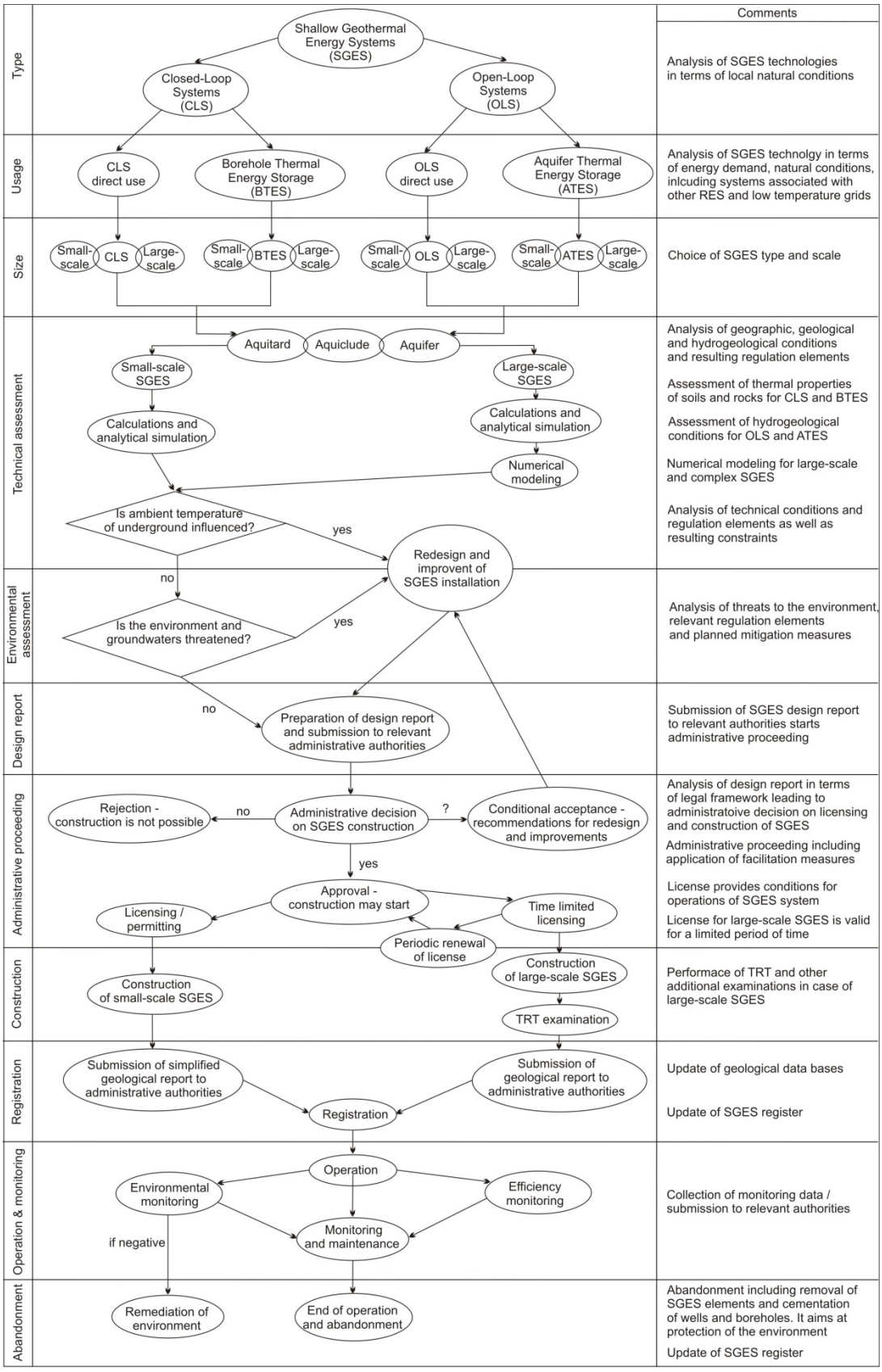


Fig. 25 Recommended workflow for lifespan of SGES system, including administrative proceeding in terms of legal regulations. Partly adapted after Hähnlein et al. 2013

11 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The following conclusions resulting from the pursued studies and analysis of the questionnaire on the national SGE legal framework in the MUSE partner countries can be drawn:

- The EU legal framework on energy and climate, including RES and RED II Directives, explicitly recognizes the resource of geothermal energy and their significant role in energy transition and decarbonisation of economy. The legal regulations on national level often do not facilitate a proper inclusion of SGE in the energy mix for heating and cooling;
- There is a more or less common understanding of SGE concept however the lack of a unique SGE definition on European level results in imprecise legal interpretation of an issue in the EU member states and majority of European countries. The most appropriate criteria to define SGE are based on depth and temperature concept;
- Use of SGE is not explicitly regulated on EU level and lies in the national competences referring often to several regulation areas, such as mining, geology, water, environment, energy, construction, energy, etc. Legal regulation systems are strongly heterogeneous and fragmented. Only few examples of laws dedicated to SGE, both CLS and OLS, exist;
- The legally binding regulations are often supported by the guidelines, recommendations, standards and best practices referring mainly to technical and environmental aspects, whereas the guidelines related to the legal issues are rather rare. Taking into account that legislation is usually complex and fragmented and based on exceptions, the guidelines describing step-by-step ways of action would be particularly useful;
- The GSOs are usually not involved in legal procedures related to SGE including licensing. A number of surveys play an important advisory role and take part in assessment of the current legal regulations as well as influencing improvement of existing legislation and development of new legislation. Some GSOs were involved in elaboration of the guidelines on design and drilling of boreholes for SGES (SGU). Among the studied GSOs, only IGME is involved in enforcement of law and legal regulations, controlling, legal consulting, assessment of legal regulations and with all of these capabilities it can influence improvement and development of new legislation on national level;
- Other examples of the GSO involvement in legislative policy are GBA which consults regional authorities in providing information and amending licensing procedures in Austria and BRGM which elaborates geothermal maps including the diverse regulation zones at the national and regional levels in France;
- Licensing exists in a prevailing number of countries, though it is not a prerequisite for successful development of SGES in the country, e.g. Sweden. In general, existing application and licensing procedures differ substantially from country to country. In several countries licensing comprises certain facilitating measures. Nonetheless, both legal regulations and administrative procures, must be still unified and simplified in a number of countries. In that context there is a number of competences which could be passed from national to regional or local level, under the condition the standard of SGE implementation is ensured by professional design and construction of installation;
- Implementation of the identified facilitating measures of the SGE application procedure is often limited to the following: *no application fee*, *no license fee*, *max time limit to issue a licence* and *unlimited license length*. The e-government concept and e-services, including the *one-stop-shop* and *on-line application* measures are still not employed to a sufficient degree. Implementation of

electronic means based measures as well as use of possibilities provided by the Internet and electronic mail should be further developed and introduced;

- The register of SGE installations exists in the selected countries only and, in addition, usually it is not fully comprehensive or continuously updated. Lack of appropriate register of SGE installations was indicated as a barrier for development of SGE market in a number of countries;
- SGE monitoring is normally not enforced by the authorities, however in some countries (Austria, Belgium and Spain) monitoring is applied to larger installations and in several countries to all OLS installations. The recommendations on monitoring, on both efficiency of SGE installations and environmental aspects are available in several countries. The most commonly monitored parameters for efficiency of SGE installations are volume and temperature of extracted and injected water, while for OLS groundwater head, groundwater temperature and in some countries physiochemical parameters and chemical composition of groundwater;
- Monitoring of SGES, referring to both efficiency of the system and environment, is required in limited cases and even if obligatory, it is not commonly performed due to high costs. If implemented, it refers normally to the basic technical, physicochemical and environmental parameters including number of operation hours, extraction and injection, or inlet and outlet, temperatures and groundwater table position, physicochemical water parameters. Regularity of monitoring for the individual parameters is significantly diverse;
- The use of SGE and construction of SGES substantially depends on local geographic, geological and hydrogeological settings, therefore a thorough knowledge on local conditions is crucial and must be a part of legal regulations and administrative procedures;
- Decommissioning of the abandoned SGE boreholes is mostly regulated by law referring to all types of boreholes. There is an urgent need for establishment of legal rules for decommissioning of the CLS systems;
- Based on the flowcharts showing legal and administrative procedures applied to the SGES in the project partners' countries a workflow for the diverse phases of the entire system lifespan was proposed. This includes major facts and decisions referring to design of the system, legal regulations, administrative proceeding and conditions of operation of SGES. Nevertheless, its application in different countries would strongly depend on organisation and competences of administration, GSO and other institutions as well as on national legal context and would significantly differ from country to country.

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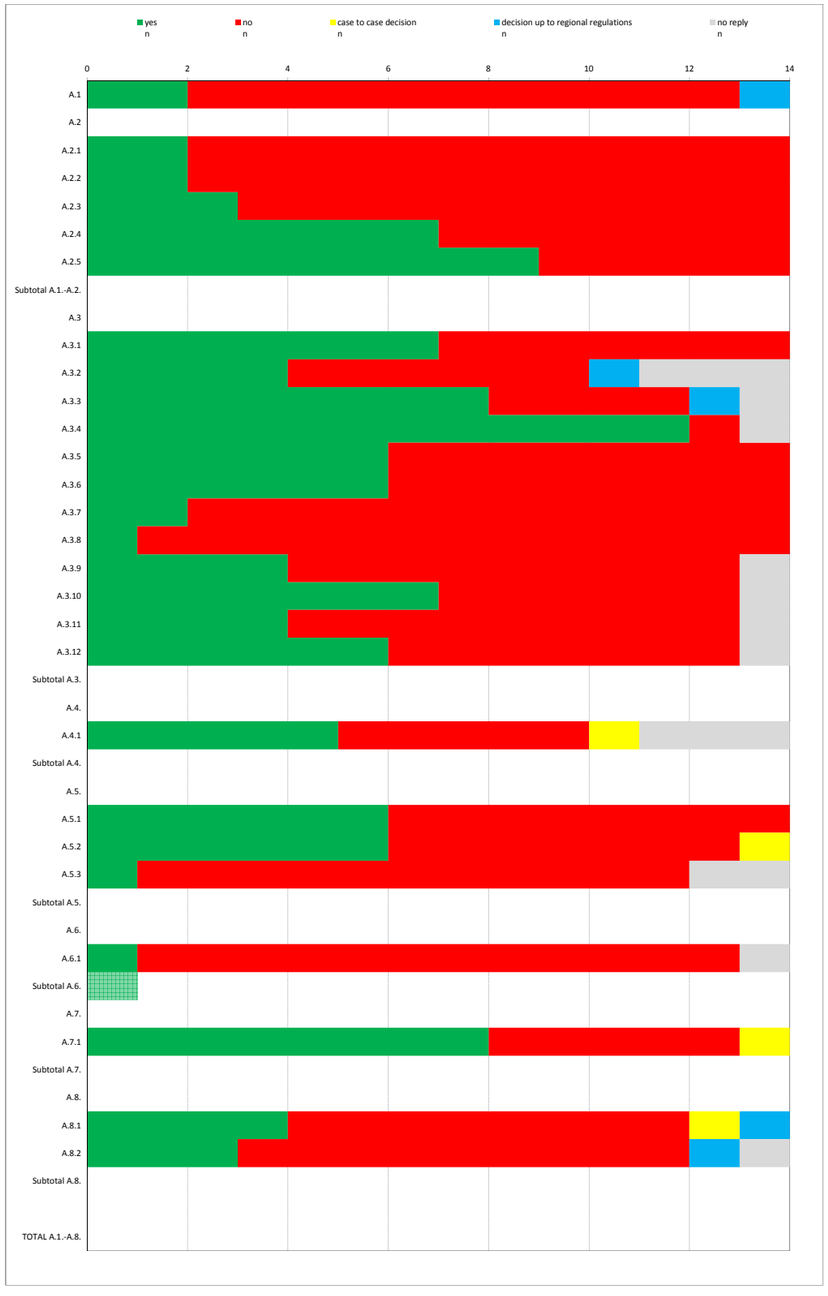
#	Appendix IA Results of partners' questionnaire, part A, closed questions: Legal regulations and licencing procedures on CLS	# Partner acronym country code	P01 GBA AT	P02 NERC UK	P04 HGI-CGS HR	P05 CGS CZ	P06 BRGM FR	P07 GSI IE	P08 RBINS-GSB BE	P09 GeoZS SI	P10 IGME ES	P11 SGU SE	P12 TNO NL	P13 PIG-PIB PL	P14 SGIDS SK	P16 GEUS DK	yes n	no n	case to case decision n	decision up to regional regulations n	no reply n	total replies n	total respondents* n	yes %	no %	case to case decision %	decision up to regional regulations %	no reply %	total replies %	total respondents* %
A.1	**1. Existing legal definition of SGE (CLS and OLS)**		no	no	yes	no	yes	no	decision up to regional regulations	no	no	no	no	no	no	no	2	11	0	1	0	14	14	14,29%	78,57%	0,00%	7,14%	0,00%	100,00%	100,00%
A.2	**2. Regulations on use of SGE** Is your GSO involved in legislation on use of SGE referring to the following aspects:																												
A.2.1	2.1 GSOs involved in law and legal regulations enforcement		no	no	no	no	no	no	no	no	yes	no	no	no	yes	no	2	12	0	0	0	14	14	14,29%	85,71%	0,00%	0,00%	0,00%	100,00%	100,00%
A.2.2	2.2 GSOs involved in controlling		no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	2	12	0	0	0	14	14	14,29%	85,71%	0,00%	0,00%	0,00%	100,00%	100,00%
A.2.3	2.3 GSOs involved in legal consulting		yes	no	no	no	no	no	no	no	yes	no	yes	no	no	no	3	11	0	0	0	14	14	21,43%	78,57%	0,00%	0,00%	0,00%	100,00%	100,00%
A.2.4	2.4 GSOs involved in assessment of legal regulations		no	no	no	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	7	7	0	0	0	14	14	50,00%	50,00%	0,00%	0,00%	0,00%	100,00%	100,00%
A.2.5	2.5 GSOs involved in influencing improvement of existing legislation and development of new legislation		yes	no	no	no	yes	no	yes	yes	yes	no	yes	yes	yes	yes	9	5	0	0	0	14	14	64,29%	35,71%	0,00%	0,00%	0,00%	100,00%	100,00%
Subtotal A.1.-A.2.																	**25**	**58**	**0**	**1**	**0**	**84**	**84**	**29,76%**	69,05%	**0,00%**	**1,19%**	**0,00%**	**100,00%**	**100,00%**
A.3	**3. Application for SGES installations and licensing (permitting)**																												
A.3.1	3.1 Is the official application for SGES installation and their further use legally regulated and obligatory?		yes	no	no	no	yes	no	yes	no	yes	no	yes	yes	no	yes	7	7	0	0	0	14	14	50,00%	50,00%	0,00%	0,00%	0,00%	100,00%	100,00%
A.3.2	3.2 If yes, do the legal regulations on SGES comprise also licensing (permitting) procedures?		decision up to regional regulations	no	no	no	no		yes	no	no		yes	yes		yes	4	6	0	1	3	11	14	28,57%	42,86%	0,00%	7,14%	21,43%	78,57%	100,00%
A.3.3	3.3 Are the application procedures the same for the whole country?		yes	decision up to regional regulations	yes	yes	yes		no	yes	no	no	no	yes	yes	yes	8	4	0	1	1	13	14	57,14%	28,57%	0,00%	7,14%	7,14%	92,86%	100,00%
A.3.4	3.4 Are the application procedures the same for all the applicants (for example institutional vs. individual applicants)?		yes	yes	yes	yes	yes		yes	yes	yes	yes	no	yes	yes	yes	12	1	0	0	1	13	14	85,71%	7,14%	0,00%	0,00%	7,14%	92,86%	100,00%
A.3.5	3.5 Is there any electronic (online) application procedure available?		no	yes	no	no	yes	no	yes	yes	no	no	yes	no	no	yes	6	8	0	0	0	14	14	42,86%	57,14%	0,00%	0,00%	0,00%	100,00%	100,00%
A.3.6	3.6 Is duration for proceeding of the SGES applications and granting the licenses (permits) legally regulated?		yes	yes	no	no	no	no	yes	no	no	no	yes	yes	no	yes	6	8	0	0	0	14	14	42,86%	57,14%	0,00%	0,00%	0,00%	100,00%	100,00%
A.3.7	3.7 Is the GSO involved in assessing and/or proceeding the SGES applications?		no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	2	12	0	0	0	14	14	14,29%	85,71%	0,00%	0,00%	0,00%	100,00%	100,00%
A.3.8	3.8 Is the GSO involved in granting the licences (permits)?		no	no	no	no	no	no	no	no	yes	no	no	no	no	no	1	13	0	0	0	14	14	7,14%	92,86%	0,00%	0,00%	0,00%	100,00%	100,00%
A.3.9	3.9 Is the land owner the only owner and user of the SGE resources?		no	no	yes	yes	no		no	no	no	no	no	yes	yes	no	4	9	0	0	1	13	14	28,57%	64,29%	0,00%	0,00%	7,14%	92,86%	100,00%
A.3.10	3.10 Is the length of the license (permit) legally regulated?		yes	yes	yes	no	no		yes	no	yes	no	yes	yes	no	no	7	6	0	0	1	13	14	50,00%	42,86%	0,00%	0,00%	7,14%	92,86%	100,00%
A.3.11	3.11 Are there any fees connected with assessment and proceeding of SGES applications?		no	yes	yes	no	no		no	no	yes	no	yes	no	no	no	4	9	0	0	1	13	14	28,57%	64,29%	0,00%	0,00%	7,14%	92,86%	100,00%
A.3.12	3.12 Are there any fees connected with granting the license (permit) for SGES applications?		yes	yes	yes	no	no		yes	no	yes	no	yes	no	no	no	6	7	0	0	1	13	14	42,86%	50,00%	0,00%	0,00%	7,14%	92,86%	100,00%
Subtotal A.3.																	**67**	**90**	**0**	**2**	**9**	**159**	**168**	**39,88%**	53,57%	**0,00%**	**1,19%**	**5,36%**	**94,64%**	**100,00%**
A.4.	**4. Authorities responsible for assessing applications and granting licenses (permits) for SGES installations**																												
A.4.1	4.1 Do the responsible authorities offer the applicants any information and/or support while submitting the SGES applications?		yes	no		no	yes		yes		no	no	yes	yes	no	case to case decision	5	5	1	0	3	11	14	35,71%	35,71%	7,14%	0,00%	21,43%	78,57%	100,00%
Subtotal A.4.																	**5**	**5**	**1**	**0**	**3**	**11**	**14**	**35,71%**	35,71%	**7,14%**	**0,00%**	**21,43%**	**78,57%**	**100,00%**
A.5.	**5. Requirements for operation of SGES**																												
A.5.1	5.1 Is operation of SGES legally regulated?		yes	no	no	no	no	no	yes	no	yes	no	yes	yes	no	yes	6	8	0	0	0	14	14	42,86%	57,14%	0,00%	0,00%	0,00%	100,00%	100,00%
A.5.2	5.2 Is any controlling of SGES operation required?		case to case decision	no	no	no	yes	no	yes	no	yes	no	yes	yes	no	yes	6	7	1	0	0	14	14	42,86%	50,00%	7,14%	0,00%	0,00%	100,00%	100,00%
A.5.3	5.3 If yes, is the GSO involved in the controlling procedure?		no	no	no	no	no		no	no	yes		no	no	no	no	1	11	0	0	2	12	14	7,14%	78,57%	0,00%	0,00%	14,29%	85,71%	100,00%
Subtotal A.5.																	**13**	**26**	**1**	**0**	**2**	**40**	**42**	**30,95%**	61,90%	**2,38%**	**0,00%**	**4,76%**	**95,24%**	**100,00%**
A.6.	**6. Special requirements for installation and operation of SGES**																												
A.6.1	6.1 Are the requirements concerning installation and operation of SGES in case of the pilot area (local level) different than in case of the national level?		no	no	no	no	no	no	no	no	yes		no	no	no	no	1	12	0	0	1	13	14	7,14%	85,71%	0,00%	0,00%	7,14%	92,86%	100,00%
Subtotal A.6.																	**1**	**12**	**0**	**0**	**1**	**13**	**14**	**7,14%**	85,71%	**0,00%**	**0,00%**	**7,14%**	**92,86%**	**100,00%**
A.7.	**7. Decommissioning of the redundant boreholes used for SGES**																												
A.7.1	7.1 Is decommissioning of the redundant boreholes legally required?		yes	no	no	no	yes	no	yes	yes	yes	no	yes	yes	yes	case to case decision	8	5	1	0	0	14	14	57,14%	35,71%	7,14%	0,00%	0,00%	100,00%	100,00%
Subtotal A.7.																	**8**	**5**	**1**	**0**	**0**	**14**	**14**	**57,14%**	35,71%	**7,14%**	**0,00%**	**0,00%**	**100,00%**	**100,00%**
A.8.	**8. Monitoring of SGES**																												
A.8.1	8.1 Is monitoring of SGES legally required?		decision up to regional regulations	no	no	no	yes	no	yes	no	case to case decision	no	yes	no	no	yes	4	8	1	1	0	14	14	28,57%	57,14%	7,14%	7,14%	0,00%	100,00%	100,00%
A.8.2	8.2 Is monitoring of SGES commonly applied?		decision up to regional regulations	no		no	yes	no	no	no	no	no	yes	no	no	yes	3	9	0	1	1	13	14	21,43%	64,29%	0,00%	7,14%	7,14%	92,86%	100,00%
Subtotal A.8.																	**7**	**17**	**1**	**2**	**1**	**27**	**28**	**25,00%**	60,71%	**3,57%**	**7,14%**	**3,57%**	**96,43%**	**100,00%**
TOTAL A.1.-A.8.																	**126**	**213**	**4**	**5**	**16**	**348**	**364**	**34,62%**	58,52%	**1,10%**	**1,37%**	**4,40%**	**95,60%**	**100,00%**

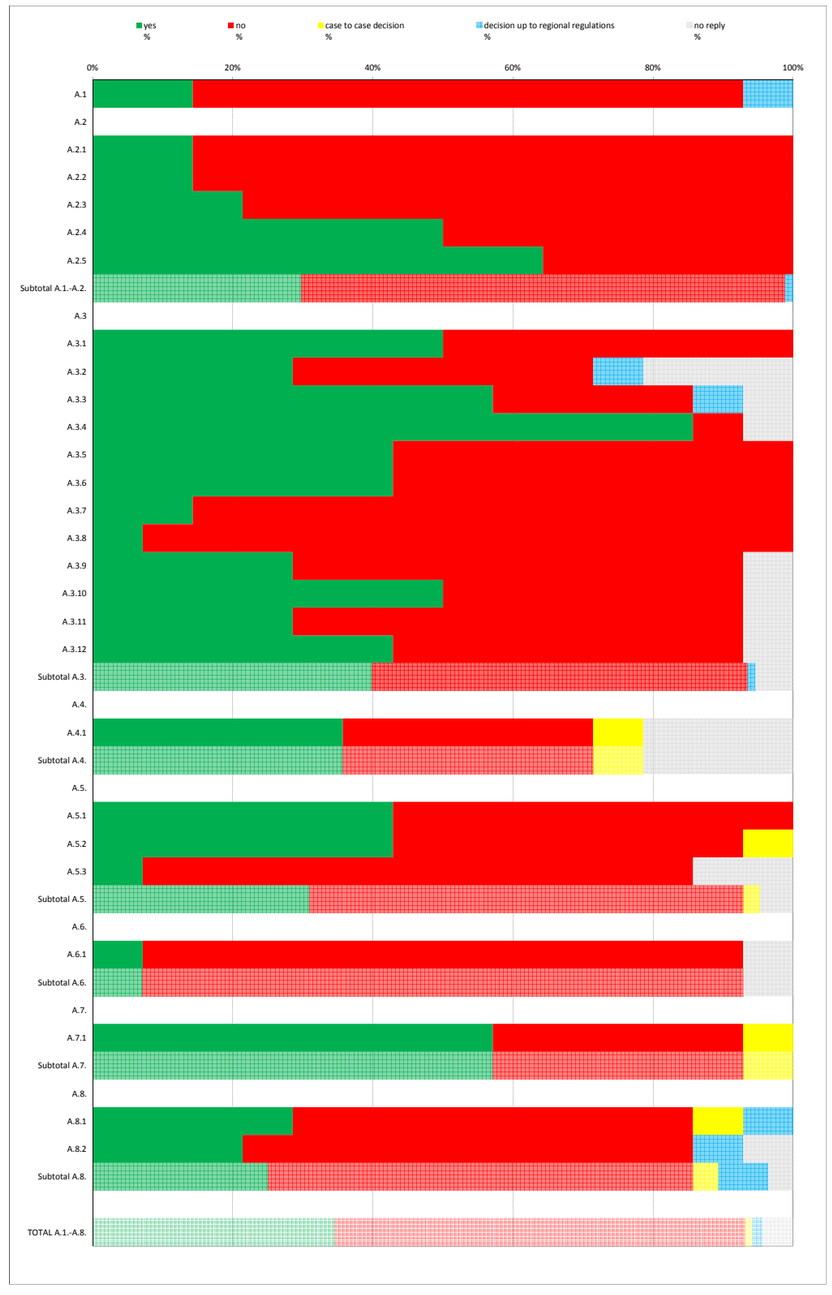
*total number of respondents is constant and equals 14, though, for calculations of percentage values in case of subtotal and total values the number of respondents was multiplied by a number of questions

																TOTAL
yes	11	6	7	3	11	0	13	6	17	2	18	13	7	12	**126**
no	11	19	17	23	15	17	12	19	8	21	8	13	18	12	**213**
case to case decision	1	0	0	0	0	0	0	0	1	0	0	0	0	2	**4**
decision up to regional regulations	3	1	0	0	0	0	1	0	0	0	0	0	0	0	**5**
no reply	0	0	2	0	0	9	0	1	0	3	0	0	1	0	**16**
total replies	26	26	24	26	26	17	26	25	26	23	26	26	25	26	**348**
total respondents	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**14**

#	Appendix IA Results of partners' questionnaire, part A, closed questions: Legal regulations and licencing procedures on CLS
A.1	**1. Existing legal definition of SGE (CLS and OLS)**
A.2	**2. Regulations on use of SGE** Is your GSO involved in legislation on use of SGE referring to the following aspects:
A.2.1	2.1 GSOs involved in law and legal regulations enforcement
A.2.2	2.2 GSOs involved in controlling
A.2.3	2.3 GSOs involved in legal consulting
A.2.4	2.4 GSOs involved in assessment of legal regulations
A.2.5	2.5 GSOs involved in influencing improvement of existing legislation and development of new legislation
Subtotal A.1.-A.2.	
A.3	**3. Application for SGES installations and licensing (permitting)**
A.3.1	3.1 Is the official application for SGES installation and their further use legally regulated and obligatory?
A.3.2	3.2 If yes, do the legal regulations on SGES comprise also licensing (permitting) procedures?
A.3.3	3.3 Are the application procedures the same for the whole country?
A.3.4	3.4 Are the application procedures the same for all the applicants (for example institutional vs. individual applicants)?
A.3.5	3.5 Is there any electronic (online) application procedure available?
A.3.6	3.6 Is duration for proceeding of the SGES applications and granting the licenses (permits) legally regulated?
A.3.7	3.7 Is the GSO involved in assessing and/or proceeding the SGES applications?
A.3.8	3.8 Is the GSO involved in granting the licences (permits)?
A.3.9	3.9 Is the land owner the only owner and user of the SGE resources?
A.3.10	3.10 Is the length of the license (permit) legally regulated?
A.3.11	3.11 Are there any fees connected with assessment and proceeding of SGES applications?
A.3.12	3.12 Are there any fees connected with granting the license (permit) for SGES applications?
Subtotal A.3.	
A.4.	**4. Authorities responsible for assessing applications and granting licenses (permits) for SGES installations**
A.4.1	4.1 Do the responsible authorities offer the applicants any information and/or support while submitting the SGES applications?
Subtotal A.4.	
A.5.	**5. Requirements for operation of SGES**
A.5.1	5.1 Is operation of SGES legally regulated?
A.5.2	5.2 Is any controlling of SGES operation required?
A.5.3	5.3 If yes, is the GSO involved in the controlling procedure?
Subtotal A.5.	
A.6.	**6. Special requirements for installation and operation of SGES**
A.6.1	6.1 Are the requirements concerning installation and operation of SGES in case of the pilot area (local level) different than in case of the national level?
Subtotal A.6.	
A.7.	**7. Decommissioning of the redundant boreholes used for SGES**
A.7.1	7.1 Is decommissioning of the redundant boreholes legally required?
Subtotal A.7.	
A.8.	**8. Monitoring of SGES**
A.8.1	8.1 Is monitoring of SGES legally required?
A.8.2	8.2 Is monitoring of SGES commonly applied?
Subtotal A.8.	
TOTAL A.1.-A.8.	

*total number of respondents is constant and equals 14, though, for calculations of percentage values in case of subtotal and total values the number of respondents was multiplied by a number of questions



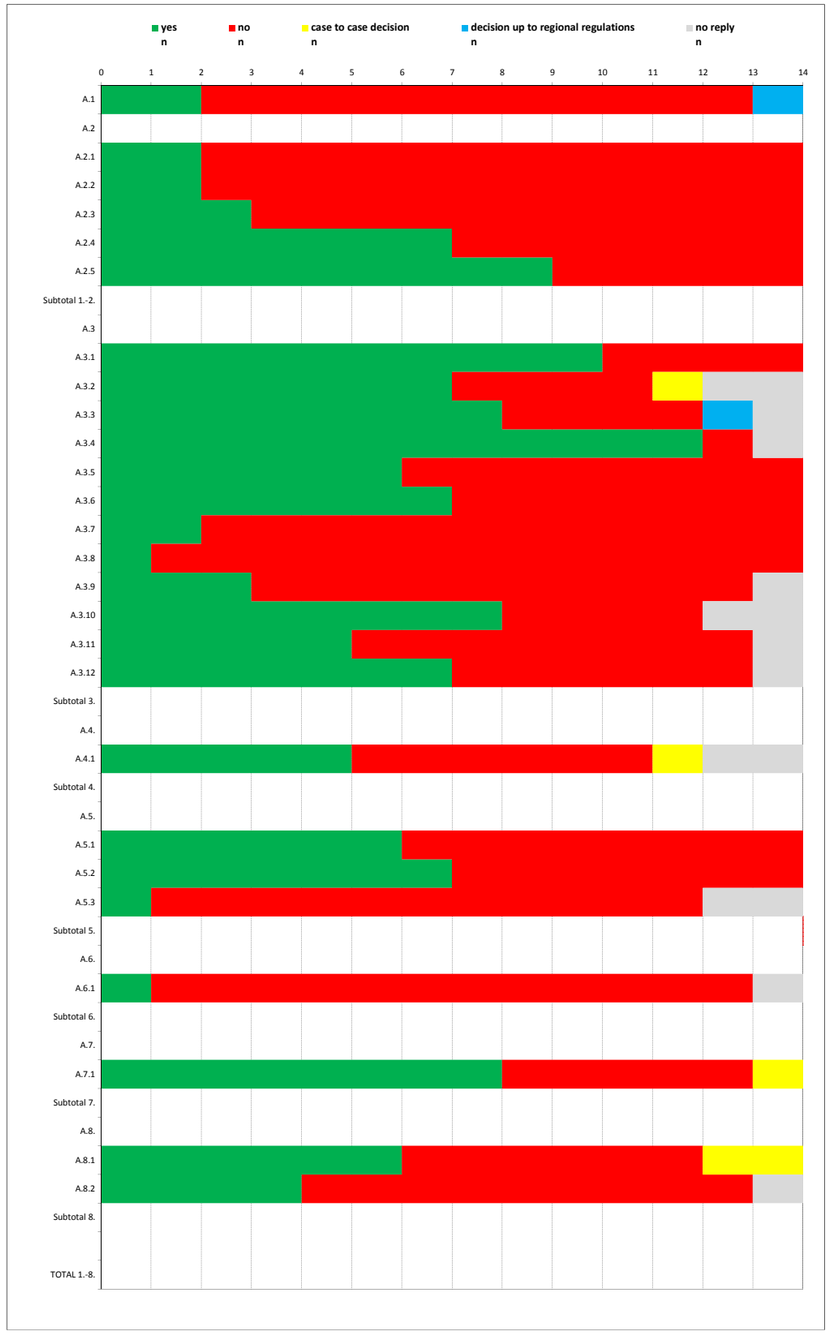


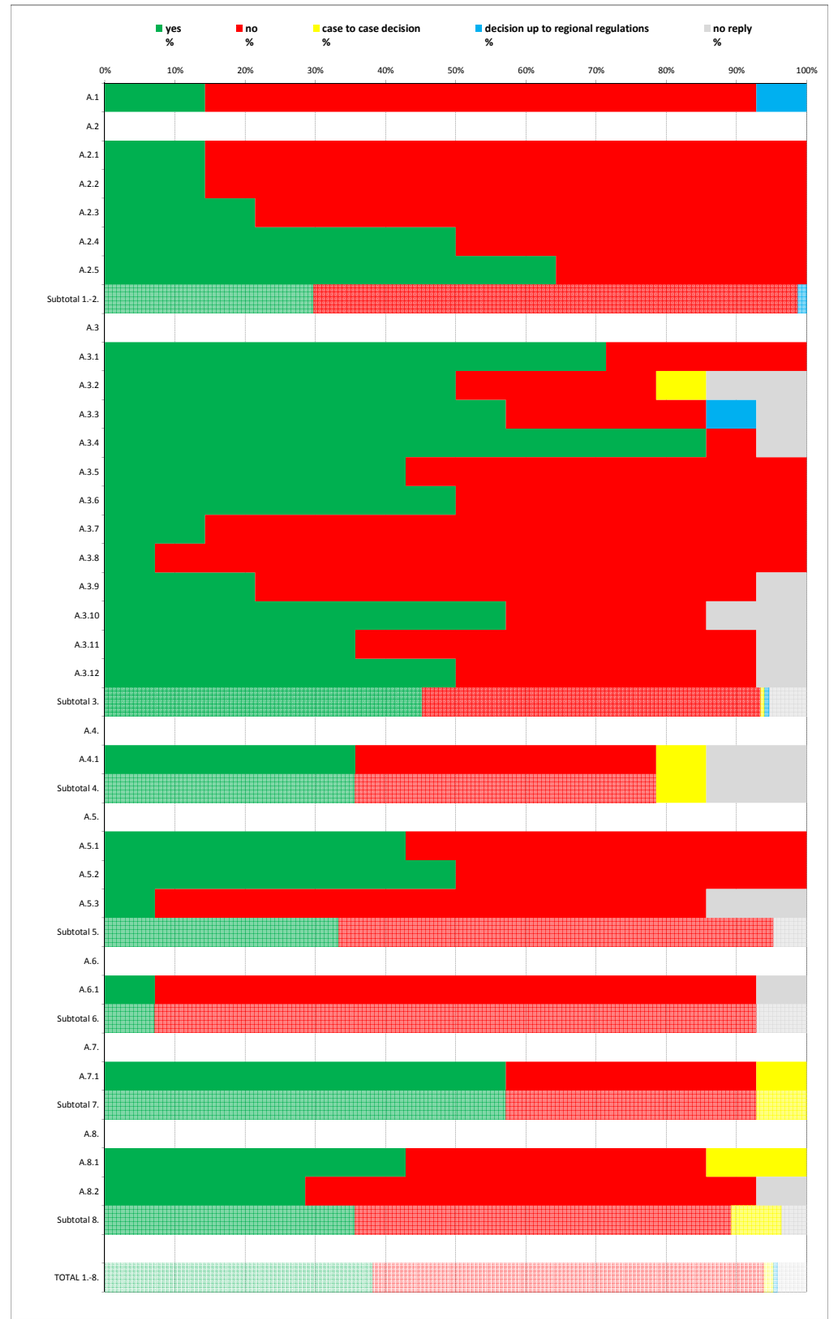
#	Appendix IB Results of partners' questionnaire, part A, closed questions: Legal regulations and licencing procedures on OLS	# Partner acronym country code	P01 GBA AT	P02 NERC UK	P04 HGI-CGS HR	P05 CGS CZ	P06 BRGM FR	P07 GSI IE	P08 RBINS-GSB BE	P09 GeoZS SI	P10 IGME ES	P11 SGU SE	P12 TNO NL	P13 PIG-PIB PL	P14 SGIDS SK	P16 GEUS DK	yes n	no n	case to case decision n	decision up to regional regulations n	no reply n	total replies n	total respondents* n	yes %	no %	case to case decision %	decision up to regional regulations %	no reply %	total replies %	total respondents* %
A.1	**1. Legal definition of SGE**		no	no	yes	no	yes	no	decision up to regional regulations	no	no	no	no	no	no	no	2	11	0	1	0	14	14	14,29%	78,57%	0,00%	7,14%	0,00%	100,00%	100,00%
A.2	**2. Regulations on use of SGE** Is your GSO involved in legislation on use of SGE referring to the following																												
A.2.1	2.1 GSOs involved in law and legal regulations enforcement		no	no	no	no	no	no	no	no	yes	no	no	no	yes	no	2	12	0	0	0	14	14	14,29%	85,71%	0,00%	0,00%	0,00%	100,00%	100,00%
A.2.2	2.2 GSOs involved in controlling		no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	2	12	0	0	0	14	14	14,29%	85,71%	0,00%	0,00%	0,00%	100,00%	100,00%
A.2.3	2.3 GSOs involved in legal consulting		yes	no	no	no	no	no	no	no	yes	no	yes	no	no	no	3	11	0	0	0	14	14	21,43%	78,57%	0,00%	0,00%	0,00%	100,00%	100,00%
A.2.4	2.4 GSOs involved in assessment of legal regulations		no	no	no	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	7	7	0	0	0	14	14	50,00%	50,00%	0,00%	0,00%	0,00%	100,00%	100,00%
A.2.5	2.5 GSOs involved in influencing improvement of existing legislation and development of new legislation		yes	no	no	no	yes	no	yes	yes	yes	no	yes	yes	yes	yes	9	5	0	0	0	14	14	64,29%	35,71%	0,00%	0,00%	0,00%	100,00%	100,00%
Subtotal 1.-2.																	**25**	**58**	**0**	**1**	**0**	**84**	**84**	**29,76%**	69,05%	**0,00%**	**1,19%**	**0,00%**	**100,00%**	**100,00%**
A.3	**3. Application for SGES installations and licensing (permitting)**																												
A.3.1	3.1 Is the official application for SGES installation and their further use legally regulated and obligatory?		yes	yes	no	no	yes	no	yes	yes	yes	no	yes	yes	yes	yes	10	4	0	0	0	14	14	71,43%	28,57%	0,00%	0,00%	0,00%	100,00%	100,00%
A.3.2	3.2 If yes, do the legal regulations on SGES comprise also licensing (permitting) procedures?		case to case decision	yes	no	no	no		yes	yes	no		yes	yes	yes	yes	7	4	1	0	2	12	14	50,00%	28,57%	7,14%	0,00%	14,29%	85,71%	100,00%
A.3.3	3.3 Are the application procedures the same for the whole country?		yes	decision up to regional regulations	yes	yes	yes		no	yes	no	no	no	yes	yes	yes	8	4	0	1	1	13	14	57,14%	28,57%	0,00%	7,14%	7,14%	92,86%	100,00%
A.3.4	3.4 Are the application procedures the same for all the applicants (for example institutional vs. individual applicants)?		yes	yes	yes	yes	yes		yes	yes	yes	yes	no	yes	yes	yes	12	1	0	0	1	13	14	85,71%	7,14%	0,00%	0,00%	7,14%	92,86%	100,00%
A.3.5	3.5 Is there any electronic (online) application procedure available?		no	yes	no	no	yes	no	yes	yes	no	no	yes	no	no	yes	6	8	0	0	0	14	14	42,86%	57,14%	0,00%	0,00%	0,00%	100,00%	100,00%
A.3.6	3.6 Is duration for proceeding of the SGES applications and granting the licenses (permits) legally regulated?		yes	yes	yes	no	no	no	yes	no	no	no	yes	yes	no	yes	7	7	0	0	0	14	14	50,00%	50,00%	0,00%	0,00%	0,00%	100,00%	100,00%
A.3.7	3.7 Is the GSO involved in assessing and/or proceeding the SGES applications?		no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	2	12	0	0	0	14	14	14,29%	85,71%	0,00%	0,00%	0,00%	100,00%	100,00%
A.3.8	3.8 Is the GSO involved in granting the licences (permits)?		no	no	no	no	no	no	no	no	yes	no	no	no	no	no	1	13	0	0	0	14	14	7,14%	92,86%	0,00%	0,00%	0,00%	100,00%	100,00%
A.3.9	3.9 Is the land owner the only owner and user of the SGE resources?		no	no	yes	yes	no		no	no	no	no	no	yes	no	no	3	10	0	0	1	13	14	21,43%	71,43%	0,00%	0,00%	7,14%	92,86%	100,00%
A.3.10	3.10 Is the length of the license (permit) legally regulated?		yes	yes	yes	no	no		yes	yes	yes	no		yes	yes	no	8	4	0	0	2	12	14	57,14%	28,57%	0,00%	0,00%	14,29%	85,71%	100,00%
A.3.11	3.11 Are there any fees connected with assessment and proceeding of SGES applications?		no	yes	yes	no	no		no	yes	yes	no	yes	no	no	no	5	8	0	0	1	13	14	35,71%	57,14%	0,00%	0,00%	7,14%	92,86%	100,00%
A.3.12	3.12 Are there any fees connected with granting the license (permit) for SGES applications?		yes	yes	yes	no	no		yes	yes	yes	no	yes	no	no	no	7	6	0	0	1	13	14	50,00%	42,86%	0,00%	0,00%	7,14%	92,86%	100,00%
Subtotal 3.																	**76**	**81**	**1**	**1**	**9**	**159**	**168**	**45,24%**	48,21%	**0,60%**	**0,60%**	**5,36%**	**94,64%**	**100,00%**
A.4.	**4. Authorities responsible for assessing applications and granting licenses (permits) for SGES installations**																												
A.4.1	4.1 Do the responsible authorities offer the applicants any information and/or support while submitting the SGES applications?		yes	no		no	yes		yes	no	no	no	yes	yes	no	case to case decision	5	6	1	0	2	12	14	35,71%	42,86%	7,14%	0,00%	14,29%	85,71%	100,00%
Subtotal 4.																	**5**	**6**	**1**	**0**	**2**	**12**	**14**	**35,71%**	42,86%	**7,14%**	**0,00%**	**14,29%**	**85,71%**	**100,00%**
A.5.	**5. Requirements for operation of SGES**																												
A.5.1	5.1 Is operation of SGES legally regulated?		yes	no	no	no	no	no	yes	no	yes	no	yes	yes	no	yes	6	8	0	0	0	14	14	42,86%	57,14%	0,00%	0,00%	0,00%	100,00%	100,00%
A.5.2	5.2 Is any controlling of SGES operation required?		yes	no	no	no	yes	no	yes	no	yes	no	yes	yes	no	yes	7	7	0	0	0	14	14	50,00%	50,00%	0,00%	0,00%	0,00%	100,00%	100,00%
A.5.3	5.3 If yes, is the GSO involved in the controlling procedure?		no	no	no	no	no		no	no	yes		no	no	no	no	1	11	0	0	2	12	14	7,14%	78,57%	0,00%	0,00%	14,29%	85,71%	100,00%
Subtotal 5.																	**14**	**26**	**0**	**0**	**2**	**40**	**42**	**33,33%**	61,90%	**0,00%**	**0,00%**	**4,76%**	**95,24%**	**100,00%**
A.6.	**6. Special requirements for installation and operation of SGES**																												
A.6.1	6.1 Are the requirements concerning installation and operation of SGES in case of the pilot area (local level) different than in case of the national level?		no	no	no	no	no	no	no	no	yes		no	no	no	no	1	12	0	0	1	13	14	7,14%	85,71%	0,00%	0,00%	7,14%	92,86%	100,00%
Subtotal 6.																	**1**	**12**	**0**	**0**	**1**	**13**	**14**	**7,14%**	85,71%	**0,00%**	**0,00%**	**7,14%**	**92,86%**	**100,00%**
A.7.	**7. Decommissioning of the redundant boreholes used for SGES**																												
A.7.1	7.1 Is decommissioning of the redundant boreholes legally required?		yes	no	no	no	yes	no	yes	yes	yes	no	yes	yes	yes	case to case decision	8	5	1	0	0	14	14	57,14%	35,71%	7,14%	0,00%	0,00%	100,00%	100,00%
Subtotal 7.																	**8**	**5**	**1**	**0**	**0**	**14**	**14**	**57,14%**	35,71%	**7,14%**	**0,00%**	**0,00%**	**100,00%**	**100,00%**
A.8.	**8. Monitoring of SGES**																												
A.8.1	8.1 Is monitoring of SGES legally required?		case to case decision	no	no	no	yes	no	yes	yes	case to case decision	no	yes	no	yes	yes	6	6	2	0	0	14	14	42,86%	42,86%	14,29%	0,00%	0,00%	100,00%	100,00%
A.8.2	8.2 Is monitoring of SGES commonly applied?		no	no		no	yes	no	no	yes	no	no	yes	no	no	yes	4	9	0	0	1	13	14	28,57%	64,29%	0,00%	0,00%	7,14%	92,86%	100,00%
Subtotal 8.																	**10**	**15**	**2**	**0**	**1**	**27**	**28**	**35,71%**	53,57%	**7,14%**	**0,00%**	**3,57%**	**96,43%**	**100,00%**
TOTAL 1.-8.																	**139**	**203**	**5**	**2**	**15**	**349**	**364**	**38,19%**	55,77%	**1,37%**	**0,55%**	**4,12%**	**95,88%**	**100,00%**

*total number of respondents is constant and equals 14, though, for calculations of percentage values in case of subtotal and total values the number of respondents was multiplied by a number of questions

															TOTAL
yes	12	8	8	3	11	0	13	13	17	2	17	13	10	12	**139**
no	12	17	16	23	15	17	12	13	8	21	8	13	16	12	**203**
case to case decision	2	0	0	0	0	0	0	0	1	0	0	0	0	2	**5**
decision up to regional regulations	0	1	0	0	0	0	1	0	0	0	0	0	0	0	**2**
no reply	0	0	2	0	0	9	0	0	0	3	1	0	0	0	**15**
total replies	26	26	24	26	26	17	26	26	26	23	25	26	26	26	**349**
total respondents	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**14**

#	Appendix IB Results of partners' questionnaire, part A, closed questions: Legal regulations and licencing procedures on OLS
A.1	**1. Legal definition of SGE**
A.2	**2. Regulations on use of SGE** Is your GSO involved in legislation on use of SGE referring to the following
A.2.1	2.1 GSOs involved in law and legal regulations enforcement
A.2.2	2.2 GSOs involved in controlling
A.2.3	2.3 GSOs involved in legal consulting
A.2.4	2.4 GSOs involved in assessment of legal regulations
A.2.5	2.5 GSOs involved in influencing improvement of existing legislation and development of new legislation
Subtotal 1.-2.	
A.3	**3. Application for SGES installations and licensing (permitting)**
A.3.1	3.1 Is the official application for SGES installation and their further use legally regulated and obligatory?
A.3.2	3.2 If yes, do the legal regulations on SGES comprise also licensing (permitting) procedures?
A.3.3	3.3 Are the application procedures the same for the whole country?
A.3.4	3.4 Are the application procedures the same for all the applicants (for example institutional vs. individual applicants)?
A.3.5	3.5 Is there any electronic (online) application procedure available?
A.3.6	3.6 Is duration for proceeding of the SGES applications and granting the licenses (permits) legally regulated?
A.3.7	3.7 Is the GSO involved in assessing and/or proceeding the SGES applications?
A.3.8	3.8 Is the GSO involved in granting the licences (permits)?
A.3.9	3.9 Is the land owner the only owner and user of the SGE resources?
A.3.10	3.10 Is the length of the license (permit) legally regulated?
A.3.11	3.11 Are there any fees connected with assessment and proceeding of SGES applications?
A.3.12	3.12 Are there any fees connected with granting the license (permit) for SGES applications?
Subtotal 3.	
A.4.	**4. Authorities responsible for assessing applications and granting licenses (permits) for SGES installations**
A.4.1	4.1 Do the responsible authorities offer the applicants any information and/or support while submitting the SGES applications?
Subtotal 4.	
A.5.	**5. Requirements for operation of SGES**
A.5.1	5.1 Is operation of SGES legally regulated?
A.5.2	5.2 Is any controlling of SGES operation required?
A.5.3	5.3 If yes, is the GSO involved in the controlling procedure?
Subtotal 5.	
A.6.	**6. Special requirements for installation and operation of SGES**
A.6.1	6.1 Are the requirements concerning installation and operation of SGES in case of the pilot area (local level) different than in case of the national level?
Subtotal 6.	
A.7.	**7. Decommissioning of the redundant boreholes used for SGES**
A.7.1	7.1 Is decommissioning of the redundant boreholes legally required?
Subtotal 7.	
A.8.	**8. Monitoring of SGES**
A.8.1	8.1 Is monitoring of SGES legally required?
A.8.2	8.2 Is monitoring of SGES commonly applied?
Subtotal 8.	
TOTAL 1.-8.	
	*total number of respondents is constant and equals 14, though, for calculations of percentage values in case of subtotal and total values the number of respondents was multiplied by a number of questions





Managing Urban Shallow Geothermal Energy
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Appendix II: Procedures and regulations for assessing applications and granting licenses (permits) on SGES
The flowcharts

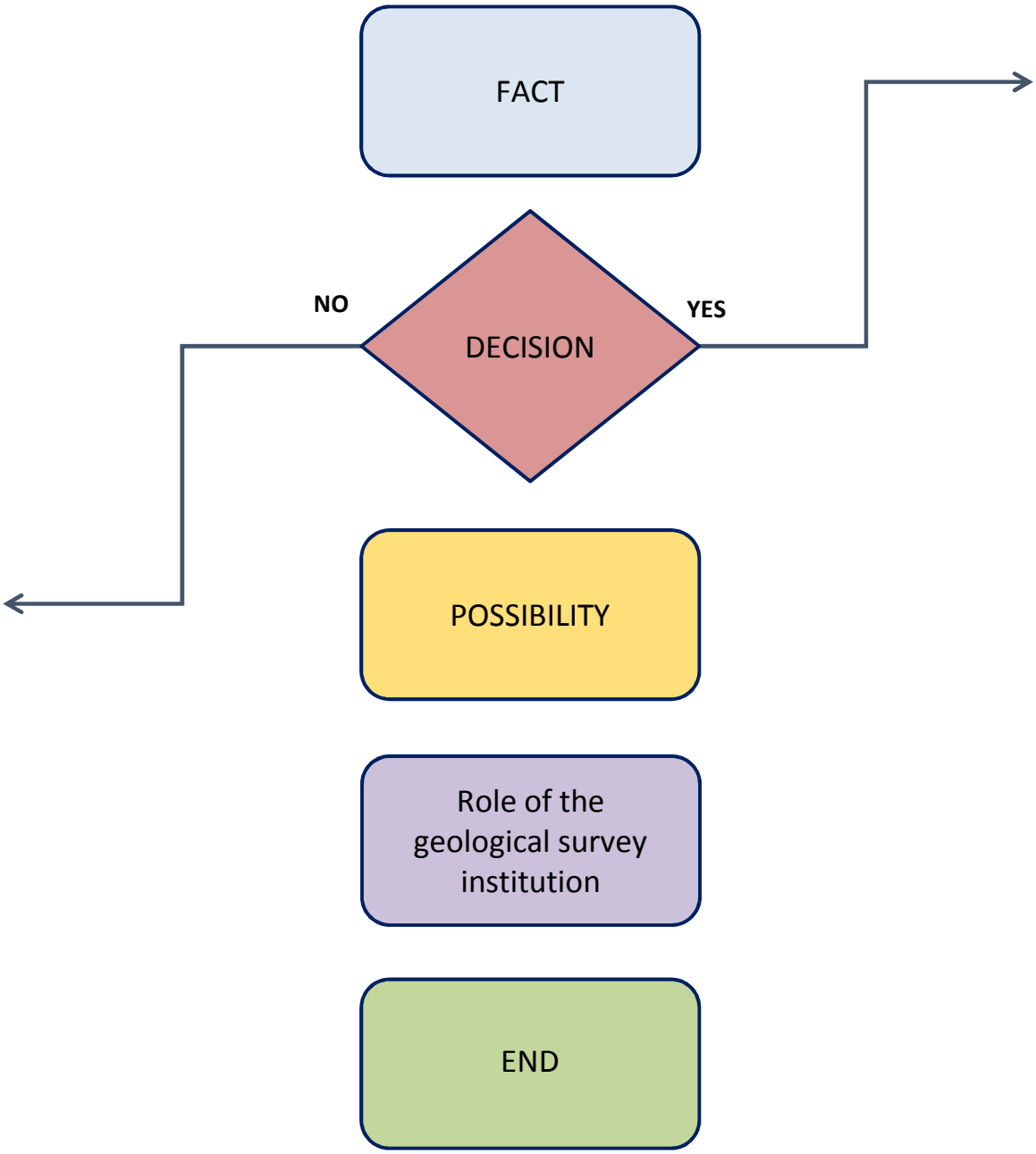
Task T.3.1. Current legal status, procedures and policies dealing with SGE use

Deliverable D.3.1
Report on the current legal framework, procedures and policies on SGE use in selected European cities

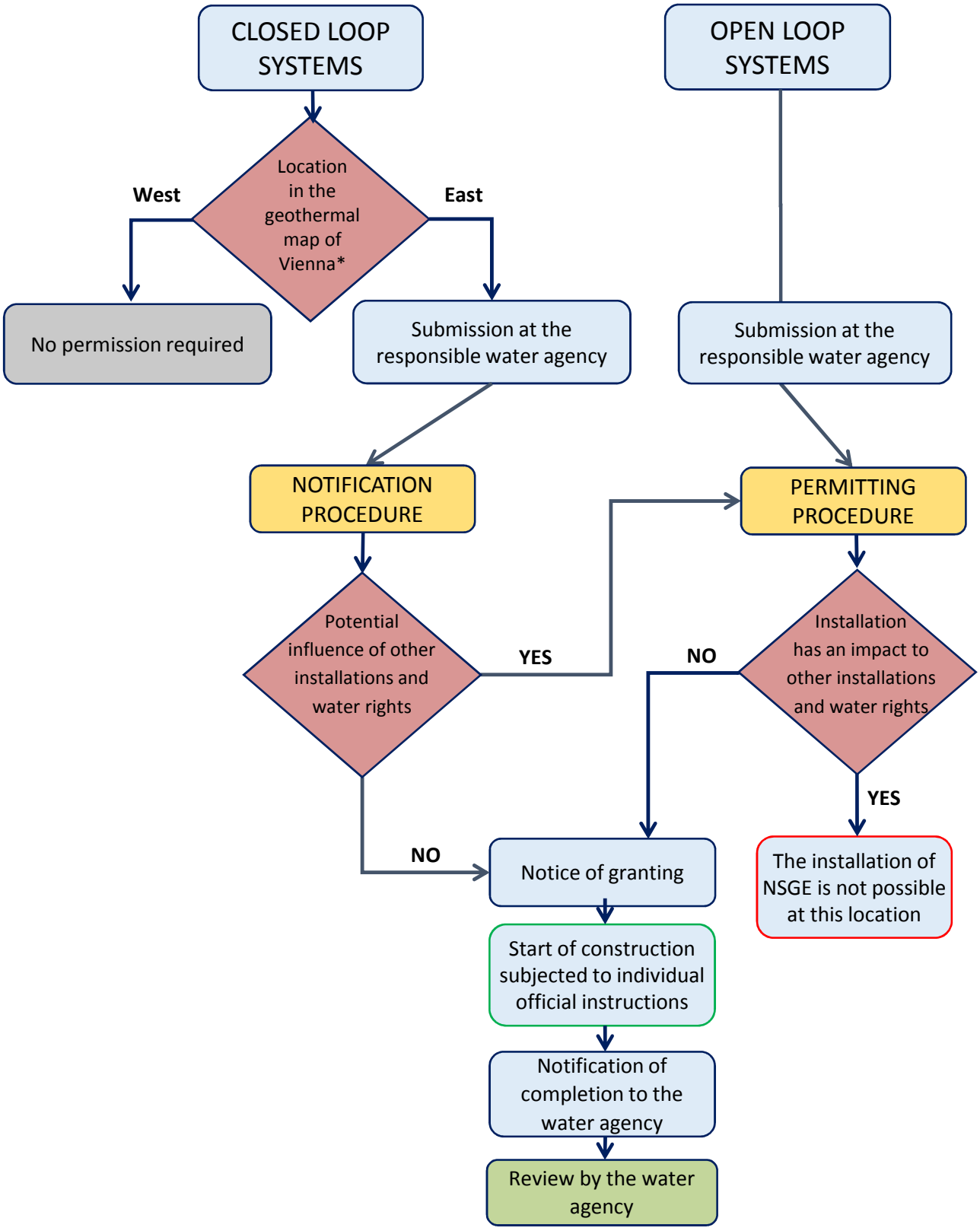
Detailed action Task T.3.1.2. Internal questionnaire on legal framework
Partner survey on specific national legal framework, procedures and policies (questionnaire covering aspects reviewed in 3.1.1) including the role of geological surveys

RESPONSES WITH APPENDIX II		
Partner acronym	**Organisation name**	**Response**
P01 GBA	Geologische Bundesanstalt	yes
P02 UKRI	United Kingdom Research and Innovation	yes
P03 ICGC	Institut Cartogràfic i Geològic de Catalunya	no
P04 HGI-CGS	Hrvatski Geološki Institut	yes
P05 CGS	Ceska Geologicka Sluzba – Czech Geological Survey	yes
P06 BRGM	Bureau de Recherches Géologiques et Minières	yes
P07 GSI	Geological Survey Ireland	yes
P08 RBINS-GSB	Royal Belgian Institute of Natural Sciences – Geological Survey of Belgium	no
P09 GeoZS	Geološki zavod Slovenije	yes
P10 IGME	Instituto Geológico y Minero de España	no
P11 SGU	Sveriges Geologiska Undersökning	yes
P12 TNO	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek TNO	yes
P13 PIG-PIB	Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy	yes
P14 SGIDS	State Geological Institute of Dionyz Stur	yes
P15 GEOINFORM	State Research and Development Enterprise State Information Geological Fund of Ukraine	no
P16 GEUS	Geological Survey of Denmark and Greenland	no

BASIC ELEMENTS

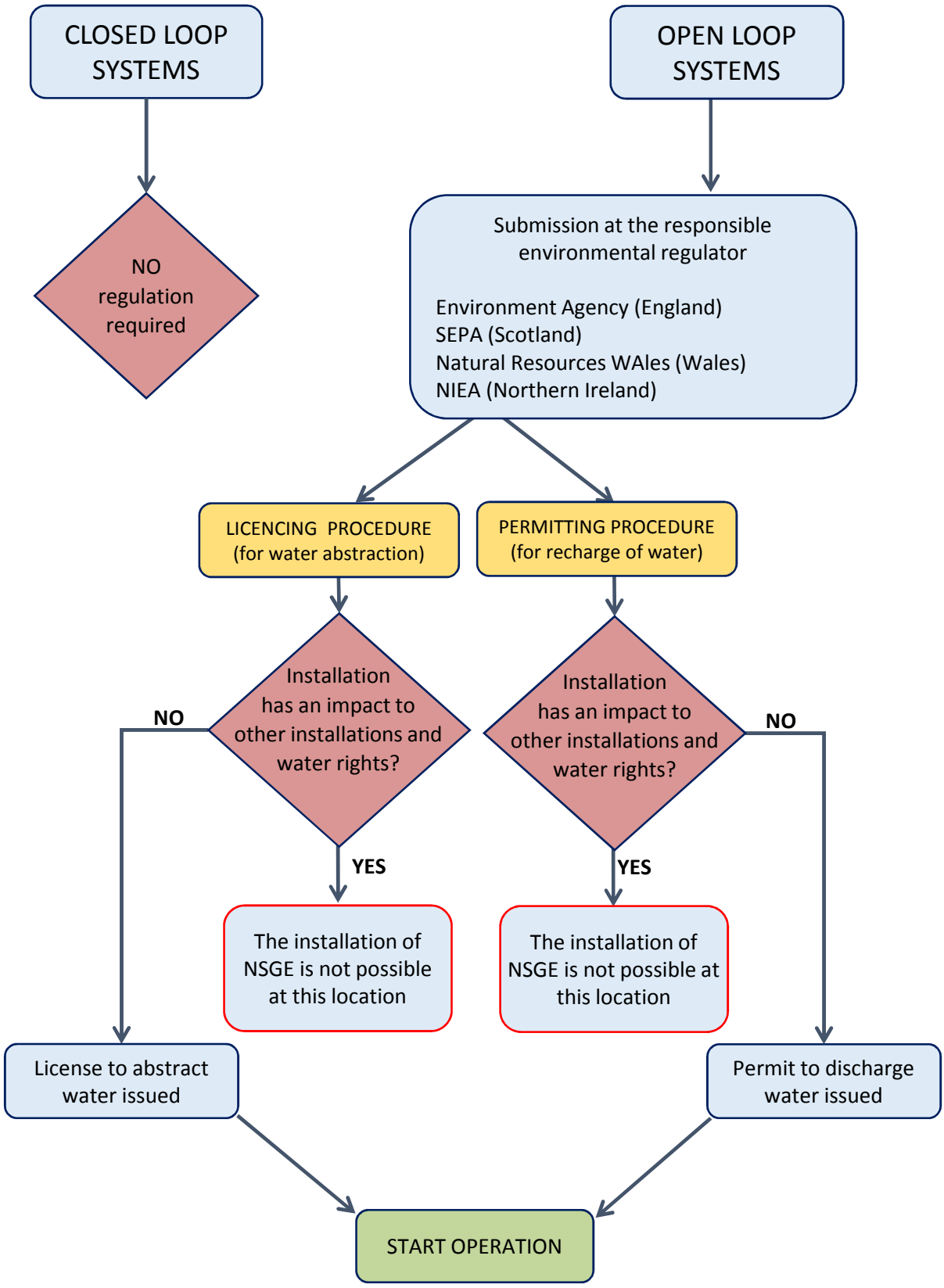


P01_GBA	Procedures and regulations for assessing applications and granting licenses (permits) on SGES in AUSTRIA

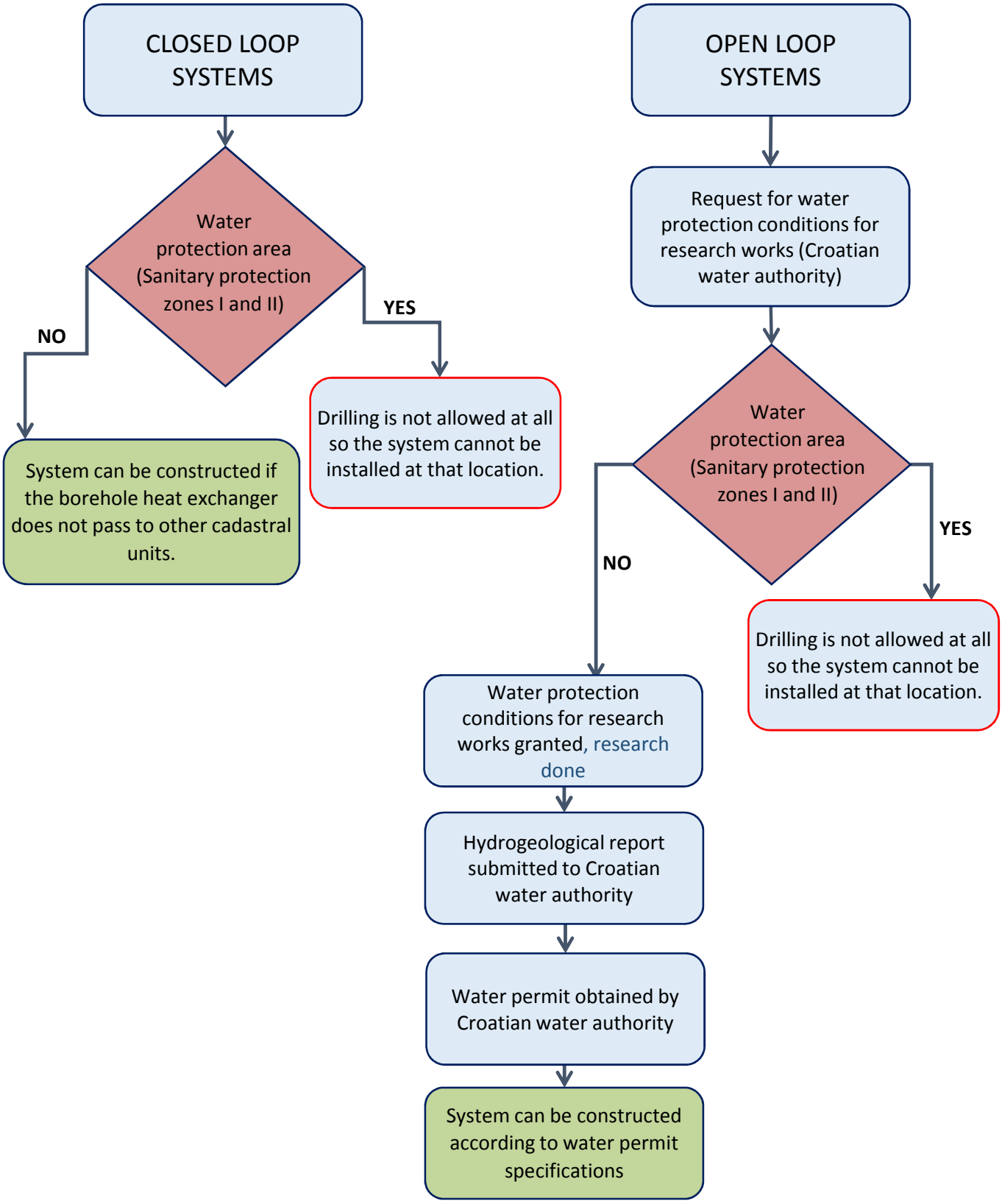


* Potential maps are accessible via the webviewer of the city of Vienna. The map contains amongst others a information about necessary licensing procedures. The information is displayed as boarder where system in the west do not need any licensing while for systems in the east a notification procedure is performed.

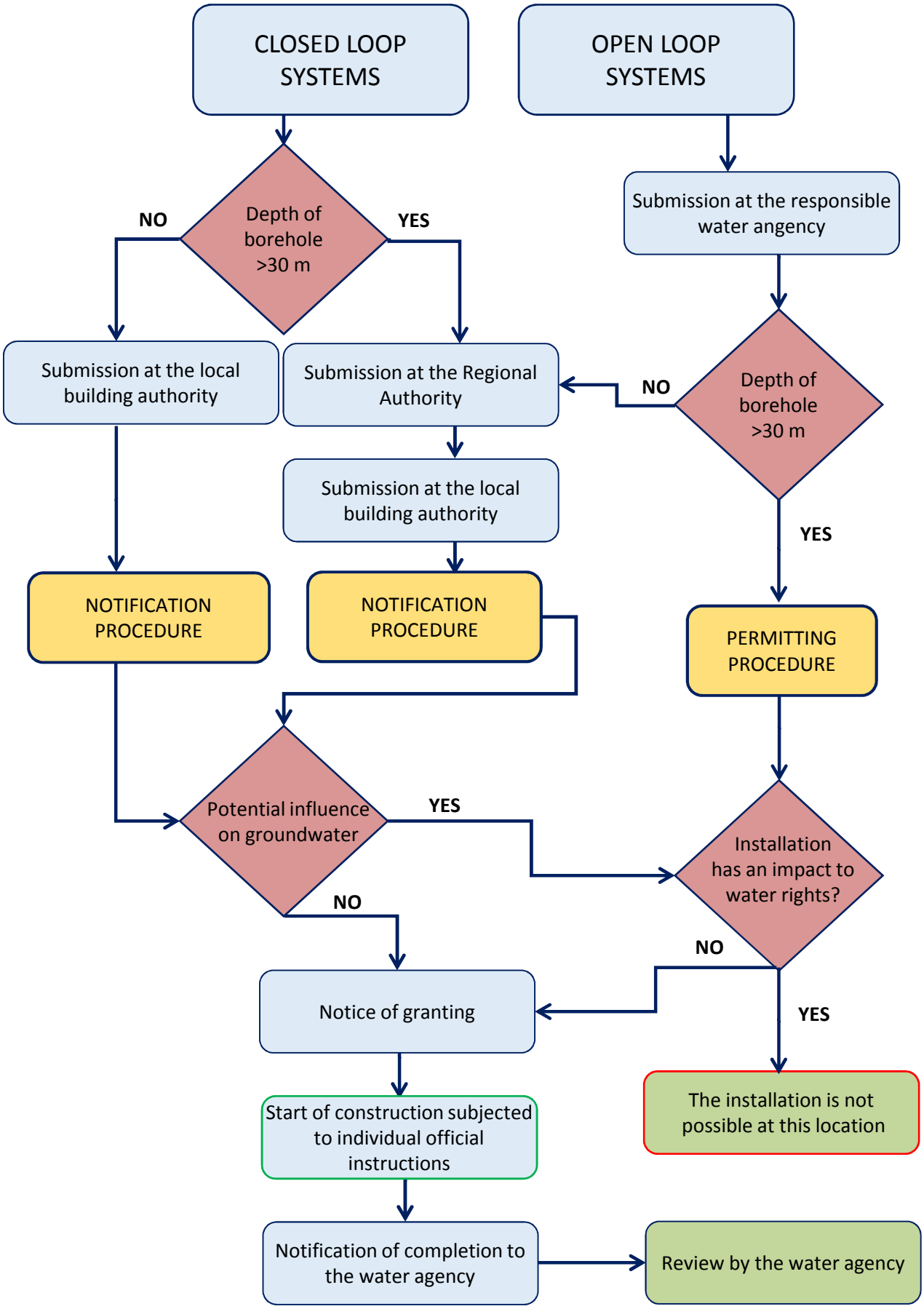
P02_BGS	Procedures and regulations for assessing applications and granting licenses (permits) on SGES in UNITED KINGDOM



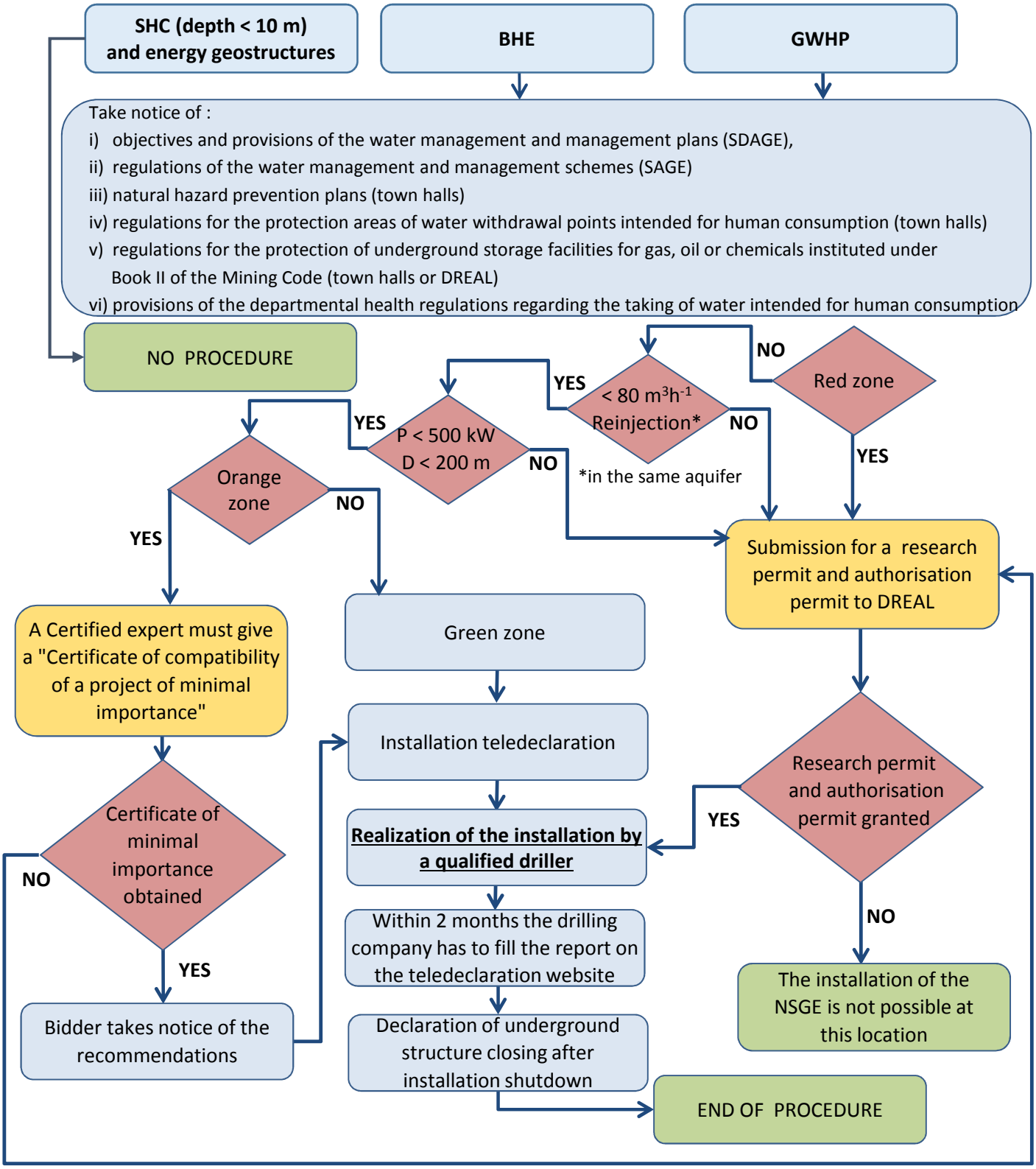
P04_HGI-CGS **Procedures and regulations for assessing applications and granting licenses (permits) on SGES in CROATIA**



P05_CGS **Procedures and regulations for assessing applications and granting licenses (permits) on SGES in CZECHIA**

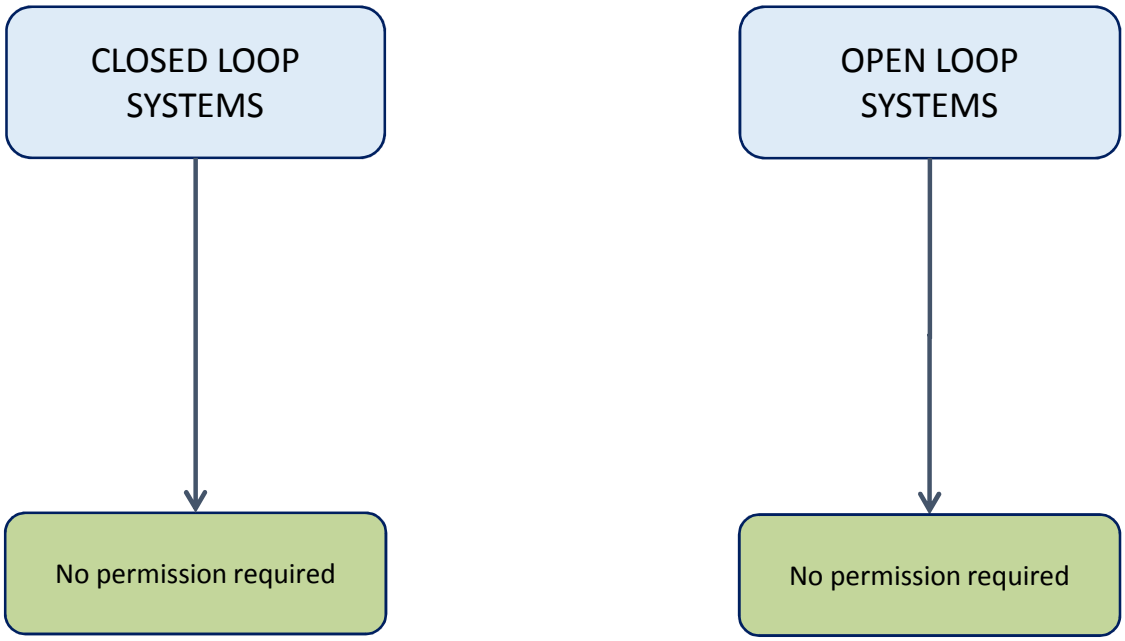


P06_BRGM **Procedures and regulations for assessing applications and granting licenses (permits) on SGES in FRANCE**

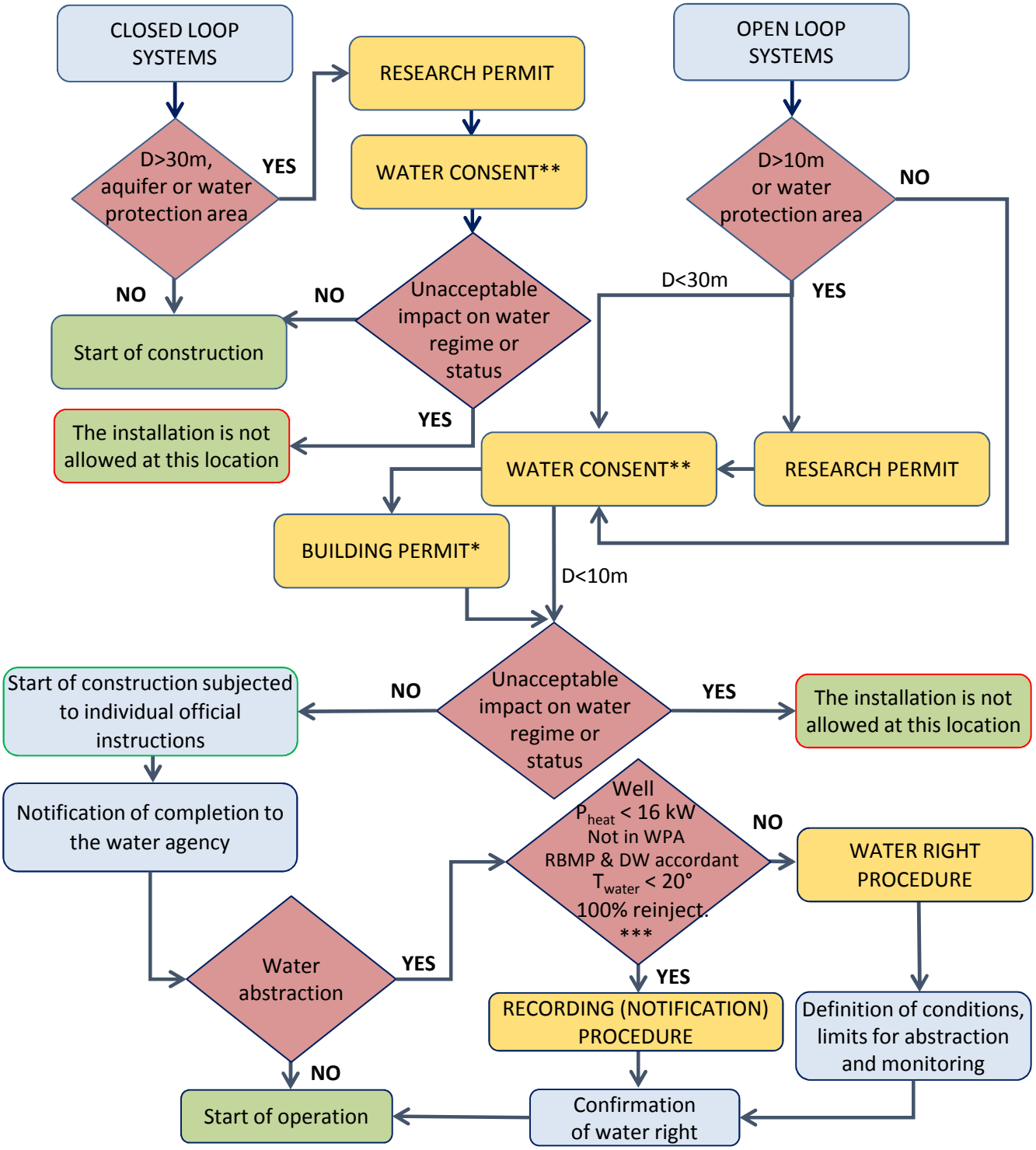


Statutory zones {defined on WEB-GIS map by special conditions, i.e. subsidence / swelling / collapsing / movement of ground [evaporites, salts, natural and artificial cavities, landslides], polluted land or groundwater, artesian groundwater, aquifer communication, rising groundwater and saltwater intrusion}:
"**green**": only declaration is needed (simplified administrative system);
"**orange**": only declaration is needed, the bidder is required to provide a "certificate of compatibility" from an expert;
"**red**" : geothermal project is subject to authorization (authorizations for research, opening of works and exploitation).

P07_GSI	Procedures and regulations for assessing applications and granting licenses (permits) on SGES in IRELAND



P09_GEO ZS **Procedures and regulations for assessing applications and granting licenses (permits) on SGES in SLOVENIA**

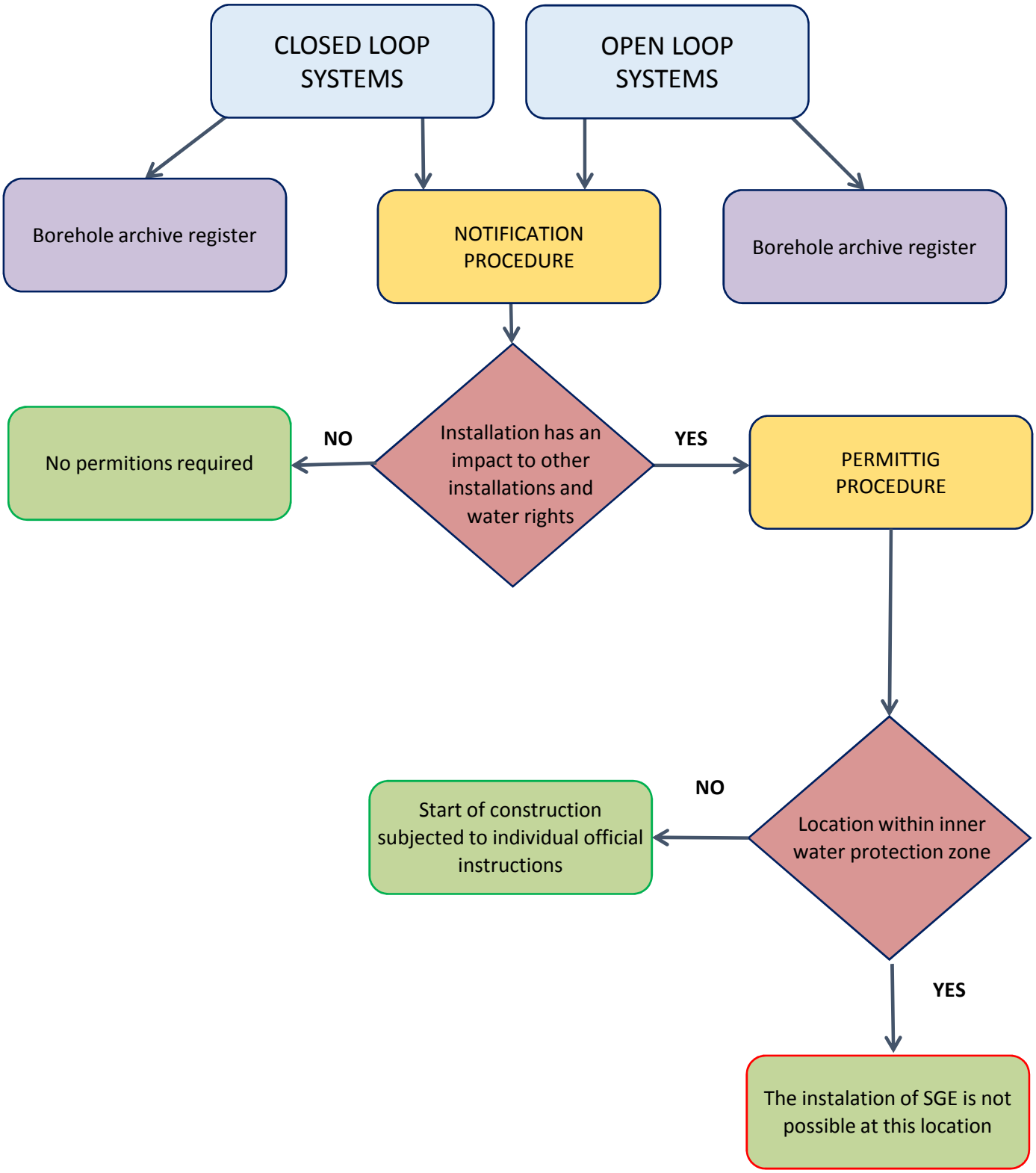


* If depth of pumping well > 10 m, building permit with construction design is required. If depth is between 10 to 30 m very simple construction design is required. If depth > 300 m, revised mining design is required.

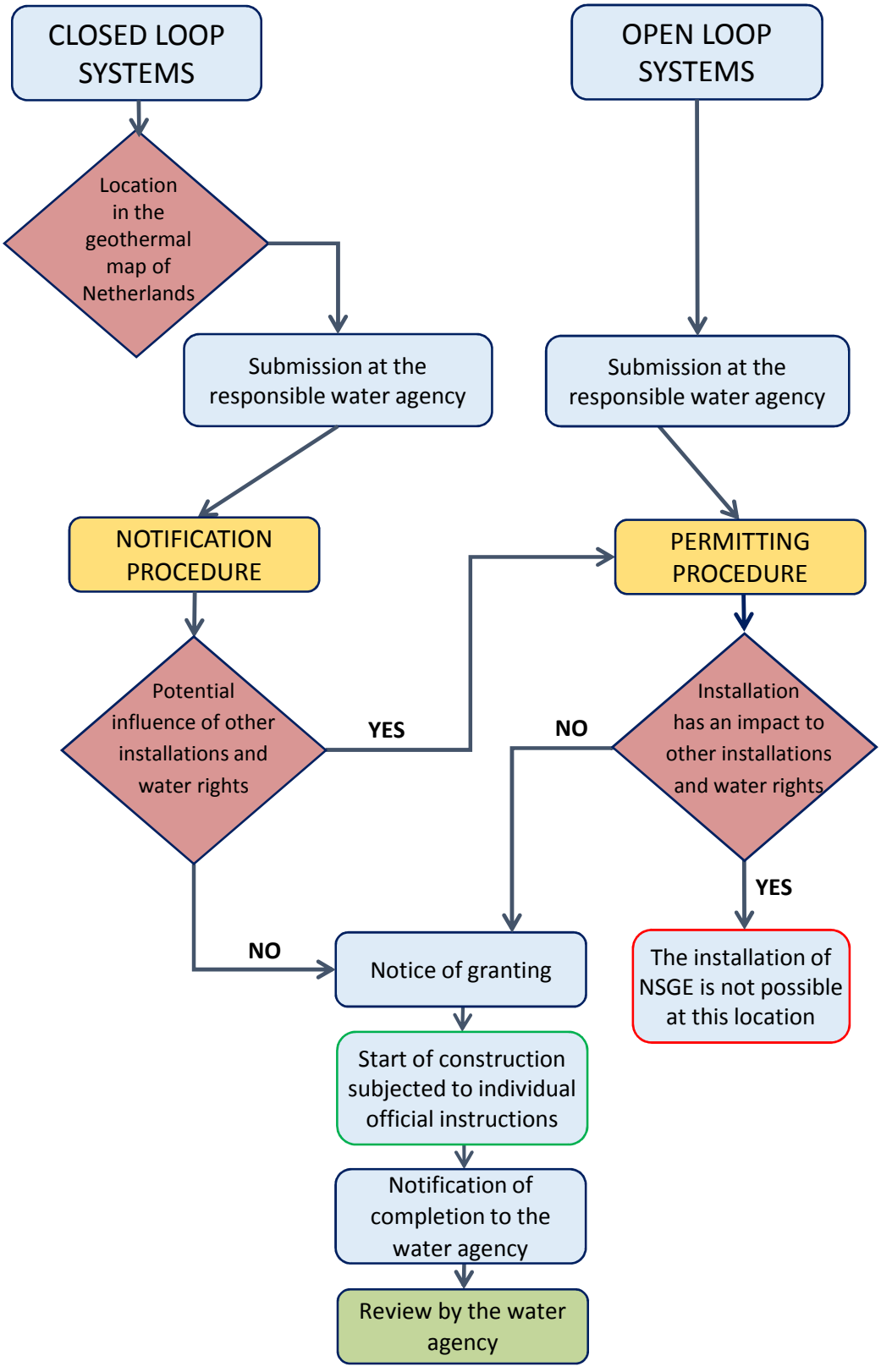
** Water consent is needed in the case of possible permanent or temporary impact on water regime or status, water abstraction or reinjection, location on coastal or waterside land, on water or other protected areas or on natural risk zones. Environmental impact assessment (EIA) is required for abstraction > 10^7 m^3/year. Review of EIA is required for installations with peak abstraction Q > 100 l/s or abstraction of mineral and thermal water.

*** Well: water abstraction from groundwater well (not from spring or surface water), WPA: Water Protection Area, RBMP: River Basin Management Plan, DW: drinking water legislation, T_{water} < 20°: not abstracted from thermal water aquifer, 100% reinject.: all abstracted water is reinjected into the same aquifer.

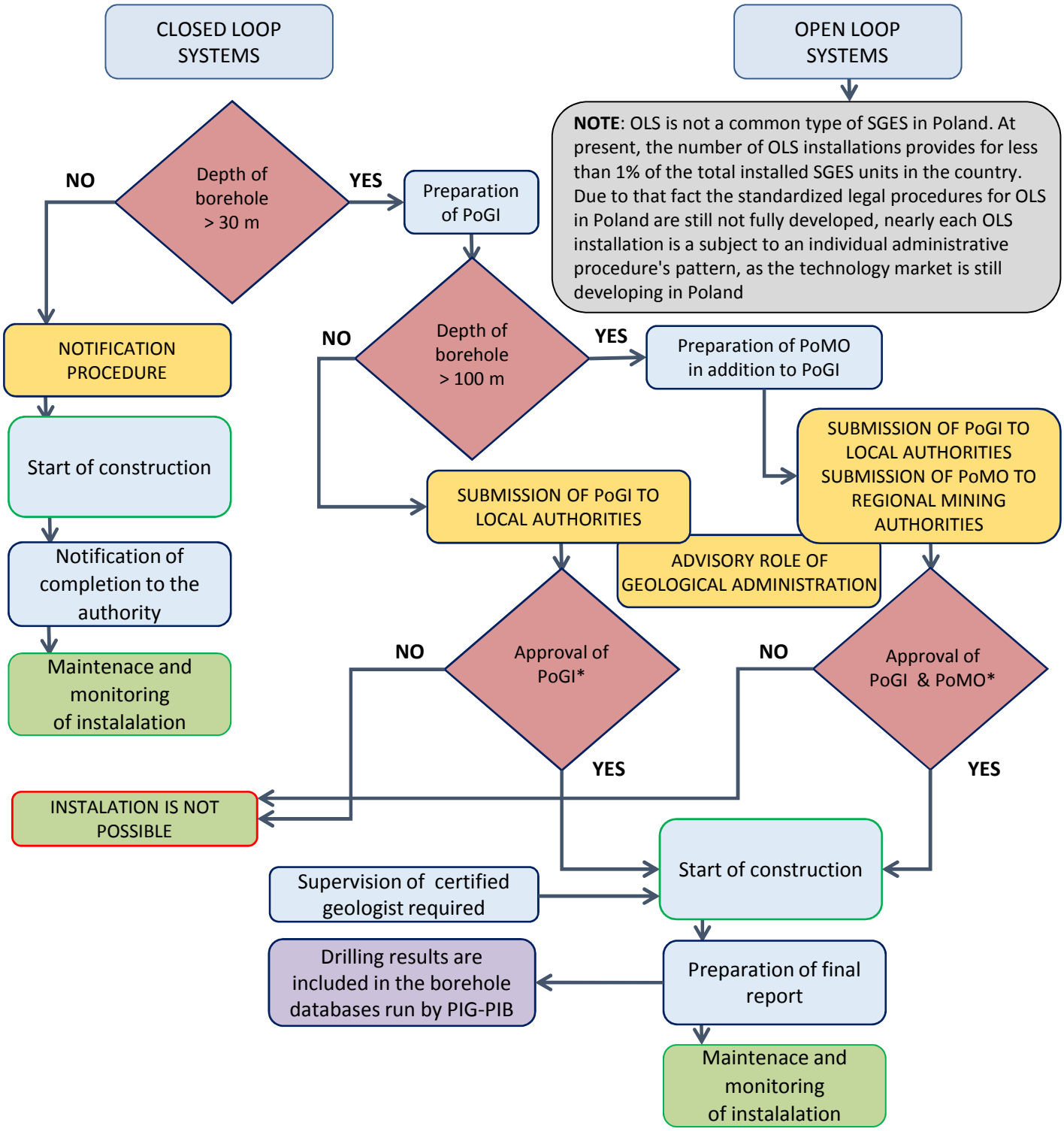
P11_SGU	Procedures and regulations for assessing applications and granting licenses (permits) on SGES in SWEDEN



P12_TNO	Procedures and regulations for assessing applications and granting licenses (permits) on SGES in THE NETHERLANDS

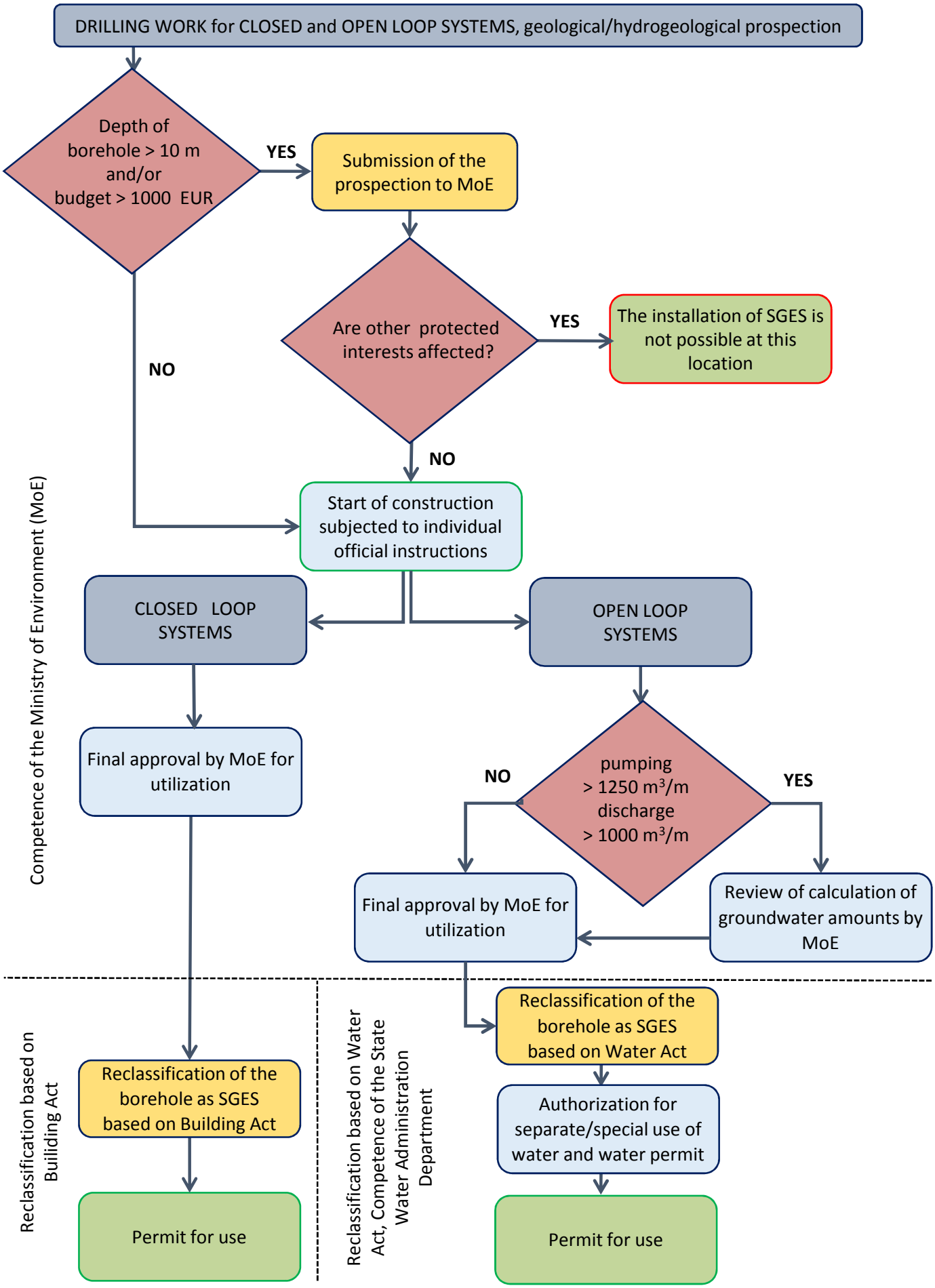


P13_PIG PIB **Procedures and regulations for assessing applications and granting licenses (permits) on SGES in POLAND**



PoGI - programme of geological investigations, includes: description of geological and hydrogeological settings, review of relevant archive data, design of drilling and construction of borehole(s), design of investigations and measurements
PoMO - programme of mining operations, includes: technical conditions for exploitation of the installation, environmental constrains, identification of risk and risk mitigation measures
Role of PIG-PIB: it can be asked for advise at any stage of the administrative procedure and construction of installation. The geological reports are stored, in the National Geological Archive run by PIG-PIB, while the drilling results are included in the borehole data base also run by PIG-PIB
* approval of PoGI and PoMO is equal to permission for drilling and construction of CLS
** final reports are submitted to the authorities in charge of approval of PoGO and PoMO

P14_SGIDS **Procedures and regulations for assessing applications and granting licenses (permits) on SGES in SLOVAKIA**



Appendix III Results of partners' questionnaire, part C, Specific geological and geographic conditions limiting SGES

Is SGES allowed under the specific conditions listed below:

	#	Specific geological and geographic conditions as the administrative or legal regulation elements	# Partner acronym country code	P01 GBA AT	P02 NERC UK	P04 HGI-CGS HR	P05 CGS CZ	P06 BRGM FR	P07 GSI IE	P08 RBINS-GSB BE	P09 GeoZS SI	P10 IGME ES	P11 SGU SE	P12 TNO NL	P13 PIG-PIB PL	P14 SGIDS SK	P16 GEUS DK	yes n	no n	case to case decision n	no reply n	total replies n	total respondents* n	yes %	no %	case to case decision %	no reply %	total replies %	total respondents* %
BOTH SYSTEMS OPEN-LOOP (GWHP) AND CLOSED-LOOP (GSHP)	1.	Artesian and confined aquifers		case to case decision	Yes	Yes	Case to case decision	Case to case decision	Yes	No	case to case decision	Yes	No	Yes	Yes	Yes	Yes	8	2	4	0	14	14	57,14%	14,29%	28,57%	0,00%	100,00%	100,00%
	2.	Shallow unconfined aquifers into which reinjection can be problematic		Yes	Yes	Yes	Case to case decision	Yes	Yes	No	case to case decision	Case to case decision	Case to case decision	Yes	Yes	Case to case decision	Case to case decision	7	1	6	0	14	14	50,00%	7,14%	42,86%	0,00%	100,00%	100,00%
	3.	Perched aquifers		Case to case decision	Yes	Yes	Case to case decision	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Case to case decision	10	1	3	0	14	14	71,43%	7,14%	21,43%	0,00%	100,00%	100,00%
	4.	Multi-layered aquifer systems		Case to case decision	Yes	Yes	Case to case decision	Case to case decision	Yes	Yes	case to case decision		Case to case decision	Yes	Yes	Yes	Case to case decision	7	0	6	1	13	14	50,00%	0,00%	42,86%	7,14%	92,86%	100,00%
	5.	Mineral and medicinal water resources		No	Case to case decision	Yes	No	Case to case decision	Yes	No	case to case decision	Yes	Case to case decision	No	Case to case decision	No		3	5	5	1	13	14	21,43%	35,71%	35,71%	7,14%	92,86%	100,00%
	6.	Thermal water resources		No	Case to case decision	Yes	Case to case decision	Case to case decision	Yes	No	case to case decision	Yes	No	Yes	Case to case decision	Yes		5	3	5	1	13	14	35,71%	21,43%	35,71%	7,14%	92,86%	100,00%
	7.	Gas emanations, natural and /or anthropogenic		Case to case decision	Case to case decision	Yes	Case to case decision	Case to case decision	Yes	No	No	Case to case decision	Case to case decision	Yes	Yes	No		4	3	6	1	13	14	28,57%	21,43%	42,86%	7,14%	92,86%	100,00%
	8.	Mining areas, including such aspects as: cone of depression in open cast mining, dewatering, land surface movement due to mining, etc.		No	Case to case decision	Yes	Yes	Case to case decision	Yes	No	case to case decision	Yes	Case to case decision	Yes	Case to case decision	case to case decision		5	2	6	1	13	14	35,71%	14,29%	42,86%	7,14%	92,86%	100,00%
	9.	Contaminated soils and groundwater		No	Case to case decision	Yes	Case to case decision	Case to case decision	Yes	No	case to case decision	No	Case to case decision	No	Yes	No	No	3	6	5	0	14	14	21,43%	42,86%	35,71%	0,00%	100,00%	100,00%
	10.	Evaporates e.g. halite, gypsum, anhydrite		Case to case decision	Yes	Yes	case to case decision	Case to case decision	Yes	No	Yes	Yes	No	Yes	Yes	Case to case decision		7	2	4	1	13	14	50,00%	14,29%	28,57%	7,14%	92,86%	100,00%
	11.	Swellable rocks e.g. anhydrite, clays		Case to case decision	Yes	Yes	Case to case decision	Case to case decision	Yes	Yes	Yes	Yes	No	Yes	Yes	Case to case decision		8	1	4	1	13	14	57,14%	7,14%	28,57%	7,14%	92,86%	100,00%
	12.	Karstic areas		Case to case decision	Yes	Yes	Case to case decision	Case to case decision	Yes	No	Yes	Yes	No	Yes	Yes	Yes		8	2	3	1	13	14	57,14%	14,29%	21,43%	7,14%	92,86%	100,00%
	13.	Water protection areas		Case to case decision	Case to case decision	Yes	Case to case decision	No	Yes	No	case to case decision	No	Yes	No	No	No	Case to case decision	3	6	5	0	14	14	21,43%	42,86%	35,71%	0,00%	100,00%	100,00%
	14.	Nature protection areas		Case to case decision	Case to case decision	Case to case decision	Case to case decision	No	Yes	No	case to case decision	No	Case to case decision	No	Case to case decision	Case to case decision	Case to case decision	1	4	9	0	14	14	7,14%	28,57%	64,29%	0,00%	100,00%	100,00%
	15.	Flood and erosion areas		Case to case decision	Yes	Yes	Case to case decision	Case to case decision	Yes	No	case to case decision	Yes	Case to case decision	No	Case to case decision	Case to case decision		4	2	7	1	13	14	28,57%	14,29%	50,00%	7,14%	92,86%	100,00%
	16.	Landslide and mass movement areas		Case to case decision	Yes	Yes	No	Case to case decision	Yes	No	case to case decision	No	Case to case decision	Yes	Case to case decision	No	No	4	5	5	0	14	14	28,57%	35,71%	35,71%	0,00%	100,00%	100,00%
	17.	Costal zones			Case to case decision	Yes	no	Case to case decision	Yes	No	case to case decision	Yes	No	Yes	Case to case decision	No	Case to case decision	4	4	5	1	13	14	28,57%	28,57%	35,71%	7,14%	92,86%	100,00%
	18.	Other *please specify if applicable*												Yes				1	0	0	13	1	14	7,14%	0,00%	0,00%	92,86%	7,14%	100,00%
	TOTAL 1.-18.																	**92**	**49**	**88**	**23**	**229**	**252**	**36,51%**	**19,44%**	**34,92%**	**9,13%**	**90,87%**	**100,00%**

*total number of respondents is constant and equals 14, though, for calculations of percentage values in case of subtotal and total values the number of respondents was multiplied by a number of questions

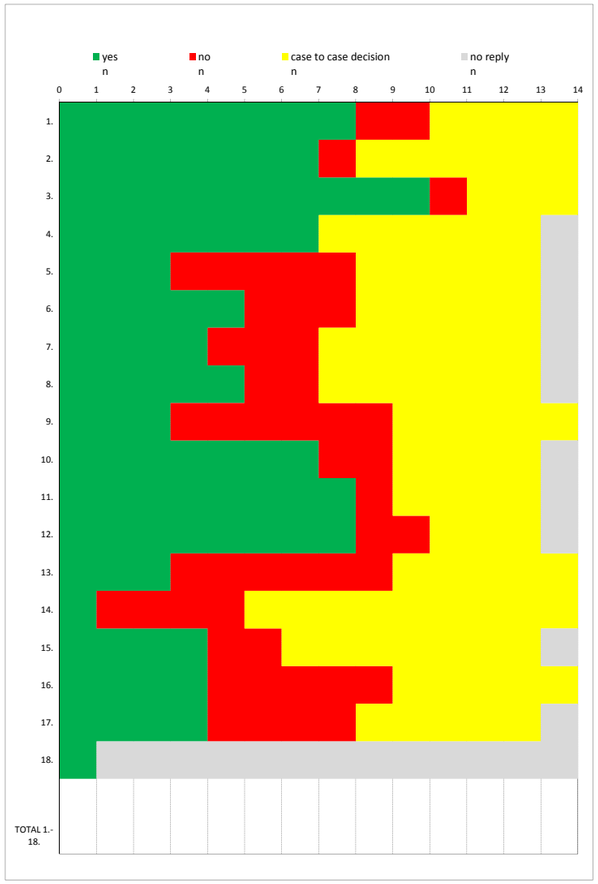
																TOTAL
yes	1	9	16	1	2	17	3	4	10	1	13	9	5	1	**92**
no	4	0	0	3	2	0	14	1	4	7	5	1	6	2	**49**
case to case decision	11	8	1	13	13	0	0	12	2	9	0	7	6	6	**88**
no reply	2	1	1	1	1	1	1	1	2	1	0	1	1	9	**23**
total replies	16	17	17	17	17	17	17	17	16	17	18	17	17	9	**229**
total respondents	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**14**

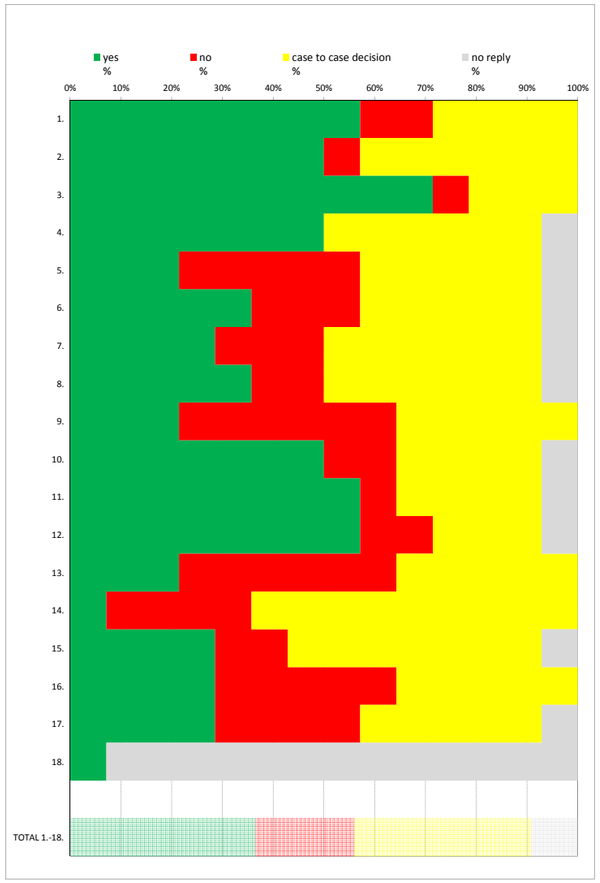
Appendix III Results of partners' questionnaire, part C, Specific geol

Is SGES allowed under the specific conditions listed below:

	#	Specific geological and geographic conditions as the administrative or legal regulation elements
BOTH SYSTEMS OPEN-LOOP (GWHP) AND CLOSED-LOOP (GSHP)	1.	Artesian and confined aquifers
	2.	Shallow unconfined aquifers into which reinjection can be problematic
	3.	Perched aquifers
	4.	Multi-layered aquifer systems
	5.	Mineral and medicinal water resources
	6.	Thermal water resources
	7.	Gas emanations, natural and /or anthropogenic
	8.	Mining areas, including such aspects as: cone of depression in open cast mining, dewatering, land surface movement due to mining, etc.
	9.	Contaminated soils and groundwater
	10.	Evaporates e.g. halite, gypsum, anhydrite
	11.	Swellable rocks e.g. anhydrite, clays
	12.	Karstic areas
	13.	Water protection areas
	14.	Nature protection areas
	15.	Flood and erosion areas
	16.	Landslide and mass movement areas
	17.	Costal zones
	18.	Other *please specify if applicable*
	TOTAL 1.-18.	

*total number of respondents is constant and equals 14, though, for calculations of percentage values in case of subtotal and total values the number of respondents was multiplied by a number of questions

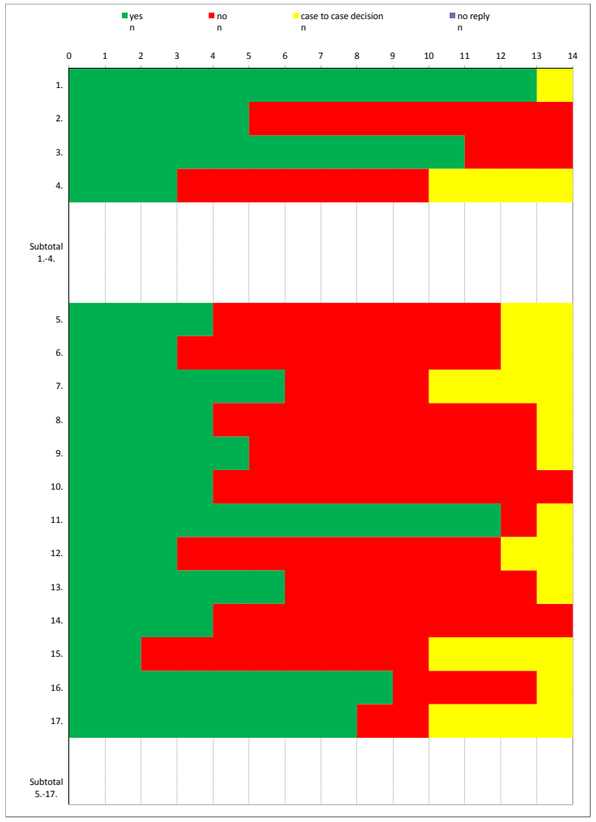


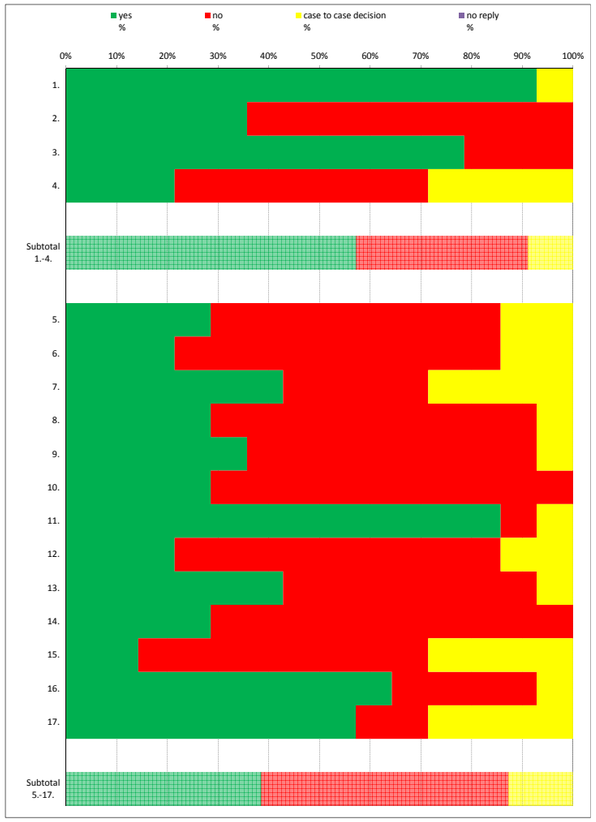


		Appendix IV Results of partners' questionnaire, part D, Regulation elements for SGES installation, implementation and operation	# Partner acronym country code	P01 GBA AT	P02 NERC UK	P04 HGI-CGS HR	P05 CGS CZ	P06 BRGM FR	P07 GSI IE	P08 RBINS-GSB BE	P09 GeoZS SI	P10 IGME ES	P11 SGU SE	P12 TNO NL	P13 PIG-PIB PL	P14 SGIDS SK	P16 GEUS DK		yes n	no n	case to case decision n	no reply n	total replies n	total respondents* n	yes %	no %	case to case decision %	no reply %	total replies %	total respondents* %
	#	Specific regulation elements																										
BOTH SYSTEMS OPEN-LOOP (GWHP) AND CLOSED-LOOP (GSHP)	1.	Is the drilling below the groundwater table allowed?		Yes	Yes	Yes	Case to case decision	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		13	0	1	0	14	14	92,86%	0,00%	7,14%	0,00%	100,00%	100,00%
	2.	Is the certification for the designers, planners and installers mandatory?		Yes	No	Yes	No	No	No	No	No	Yes	No	Yes	Yes	No	No		5	9	0	0	14	14	35,71%	64,29%	0,00%	0,00%	100,00%	100,00%
	3.	Is the certification for drilling companies mandatory?		Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes		11	3	0	0	14	14	78,57%	21,43%	0,00%	0,00%	100,00%	100,00%
	4.	Are the numerical simulations/ models required?		Case to case decision	No	No	No	No	No	Yes	No	Case to case decision	No	Yes	Case to case decision	Case to case decision	Yes		3	7	4	0	14	14	21,43%	50,00%	28,57%	0,00%	100,00%	100,00%
	Subtotal 1.-4.																		**32**	**19**	**5**	**0**	**56**	**56**	**57,14%**	**33,93%**	**8,93%**	**0,00%**	**100,00%**	**100,00%**
OPEN-LOOP SYSTEMS (GWHP)	5.	Is the minimum distance (m) to the neighbouring ground plot defined?		Yes	No	No	No	No	No	Case to case decision	Yes	No	Case to case decision	Yes	Yes	No	No		4	8	2	0	14	14	28,57%	57,14%	14,29%	0,00%	100,00%	100,00%
	6.	Is the minimum distance (m) to the neighbouring buildings defined?		Yes	No	No	No	No	No	Case to case decision	Yes	No	Case to case decision	Yes	No	No	No		3	9	2	0	14	14	21,43%	64,29%	14,29%	0,00%	100,00%	100,00%
	7.	Is the minimum distance (m) to the neighbouring groundwater wells defined?		Case to case decision	Yes	No	No	Yes	No	Yes	Case to case decision	Yes	Yes	Yes	Case to case decision	Case to case decision	No		6	4	4	0	14	14	42,86%	28,57%	28,57%	0,00%	100,00%	100,00%
	8.	Is the minimum distance (m) between the wells defined?		No	Yes	No	No	No	No	Yes	No	No	Yes	Yes	Case to case decision	No	No		4	9	1	0	14	14	28,57%	64,29%	7,14%	0,00%	100,00%	100,00%
	9.	Is the minimum distance (m) between the pumping and reinjection wells defined?		Yes	Yes	No	No	No	No	Yes	Yes	No	No	Yes	Case to case decision	No	No		5	8	1	0	14	14	35,71%	57,14%	7,14%	0,00%	100,00%	100,00%
	10.	Is the minimum distance (m) to the neighbouring closed loop systems defined?		Yes	No	No	No	No	No	Yes	No	No	Yes	Yes	No	No	No		4	10	0	0	14	14	28,57%	71,43%	0,00%	0,00%	100,00%	100,00%
	11.	Is the reinjection of used groundwater allowed?		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Case to case decision	Yes	No		12	1	1	0	14	14	85,71%	7,14%	7,14%	0,00%	100,00%	100,00%
	12.	Is the maximum allowed temperature difference (°C, K) between extracted and reinjected water defined?		Yes	Yes	No	No	No	No	No	No	Case to case decision	No	Yes	Case to case decision	No	No		3	9	2	0	14	14	21,43%	64,29%	14,29%	0,00%	100,00%	100,00%
	13.	Is the absolute allowed temperature range (°C, K) of the reinjected water defined?		Yes	Yes	No	No	Yes	No	Yes	No	Case to case decision	No	Yes	No	No	Yes		6	7	1	0	14	14	42,86%	50,00%	7,14%	0,00%	100,00%	100,00%
	14.	Is the allowed temperature change (°C, K) defined?		Yes	Yes	No	No	Yes	No	No	No	No	No	Yes	No	No	No		4	10	0	0	14	14	28,57%	71,43%	0,00%	0,00%	100,00%	100,00%
	15.	Is the groundwater table drawdown (m) defined?		Case to case decision	No	No	No	No	No	No	Case to case decision	No	Yes	Yes	Case to case decision	Case to case decision	No		2	8	4	0	14	14	14,29%	57,14%	28,57%	0,00%	100,00%	100,00%
	16.	Are the groundwater investigations (dynamics, hydrochemistry, etc.) mandatory?		Case to case decision	No	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes		9	4	1	0	14	14	64,29%	28,57%	7,14%	0,00%	100,00%	100,00%
	17.	Is the pumping test mandatory?		Case to case decision	Case to case decision	Yes	Case to case decision	Yes	No	Yes	Yes	Yes	No	Yes	Case to case decision	Yes	Yes		8	2	4	0	14	14	57,14%	14,29%	28,57%	0,00%	100,00%	100,00%
	Subtotal 5.-17.																		**70**	**89**	**23**	**0**	**182**	**182**	**38,46%**	**48,90%**	**12,64%**	**0,00%**	**100,00%**	**100,00%**

Appendix IV Results of partners' questionnaire, part D, Regulation elements for SGES installation, implementation and operation

	#	Specific regulation elements
BOTH SYSTEMS OPEN-LOOP (GWHP) AND CLOSED-LOOP (GSHP)	**1.**	Is the drilling below the groundwater table allowed?
	2.	Is the certification for the designers, planners and installers mandatory?
	3.	Is the certification for drilling companies mandatory?
	4.	Are the numerical simulations/ models required?
	Subtotal 1.-4.	
OPEN-LOOP SYSTEMS (GWHP)	**5.**	Is the minimum distance (m) to the neighbouring ground plot defined?
	6.	Is the minimum distance (m) to the neighbouring buildings defined?
	7.	Is the minimum distance (m) to the neighbouring groundwater wells defined?
	8.	Is the minimum distance (m) between the wells defined?
	9.	Is the minimum distance (m) between the pumping and reinjection wells defined?
	10.	Is the minimum distance (m) to the neighbouring closed loop systems defined?
	11.	Is the reinjection of used groundwater allowed?
	12.	Is the maximum allowed temperature difference (°C, K) between extracted and reinjected water defined?
	13.	Is the absolute allowed temperature range (°C, K) of the reinjected water defined?
	14.	Is the allowed temperature change (°C, K) defined?
	15.	Is the groundwater table drawdown (m) defined?
	16.	Are the groundwater investigations (dynamics, hydrochemistry, etc.) mandatory?
	17.	Is the pumping test mandatory?
	Subtotal 5.-17.	





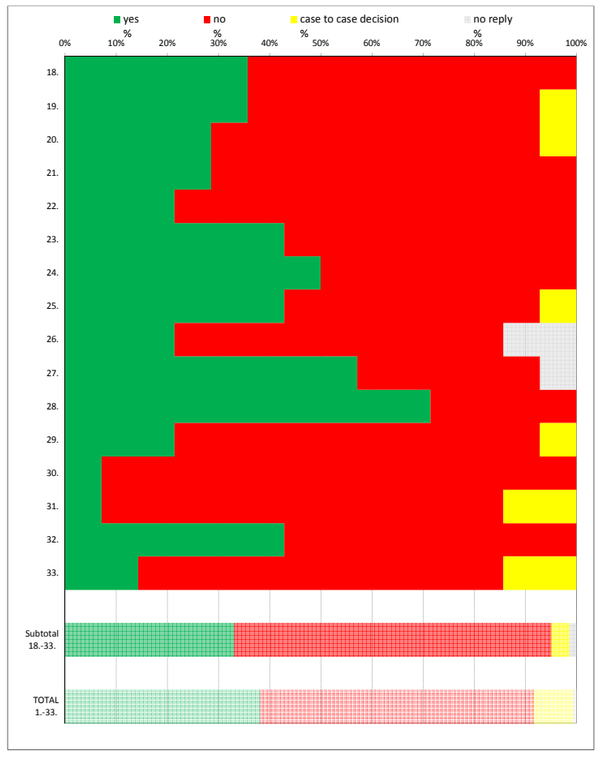
		Appendix IV Results of partners' questionnaire, part D, Regulation elements for SGES installation, implementation and operation	# Partner acronym country code	P01 GBA AT	P02 NERC UK	P04 HGI-CGS HR	P05 CGS CZ	P06 BRGM FR	P07 GSI IE	P08 RBINS-GSB BE	P09 GeoZS SI	P10 IGME ES	P11 SGU SE	P12 TNO NL	P13 PIG-PIB PL	P14 SGIDS SK	P16 GEUS DK		yes n	no n	case to case decision n	no reply n	total replies n	total respondents* n	yes %	no %	case to case decision %	no reply %	total replies %	total respondents* %
CLOSED-LOOP SYSTEMS (GSHP)	18.	Is the minimum distance (m) to the neighbouring ground plot defined?		Yes	No	No	No	Yes	No	No	Yes	No	No	Yes	Yes	No	No		5	9	0	0	14	14	35,71%	64,29%	0,00%	0,00%	100,00%	100,00%
	19.	Is the minimum distance (m) to the neighbouring buildings defined?		Yes	No	No	No	Yes	No	No	Yes	No	Case to case decision	Yes	Yes	No	No		5	8	1	0	14	14	35,71%	57,14%	7,14%	0,00%	100,00%	100,00%
	20.	Is the minimum distance (m) to the neighbouring groundwater wells defined?		No	No	No	No	Yes	No	No	No	No	Yes	Yes	Case to case decision	No	Yes		4	9	1	0	14	14	28,57%	64,29%	7,14%	0,00%	100,00%	100,00%
	21.	Is the minimum distance (m, % of well depth) between the borehole heat exchangers defined?		Yes	No	No	No	No	No	No	No	No	Yes	Yes	Yes	No	No		4	10	0	0	14	14	28,57%	71,43%	0,00%	0,00%	100,00%	100,00%
	22.	Is the target value for the average initial and input temperature (°C, K) of the heat carrier fluid defined?		Yes	No	No	No	Yes	No	No	No	No	No	Yes	No	No	No		3	11	0	0	14	14	21,43%	78,57%	0,00%	0,00%	100,00%	100,00%
	23.	Are there any specific regulations on the heat carrier fluid type?		Yes	No	No	No	Yes	No	No	No	No	Yes	Yes	Yes	No	Yes		6	8	0	0	14	14	42,86%	57,14%	0,00%	0,00%	100,00%	100,00%
	24.	Are there any specific regulations on the refrigerant type?		Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes		7	7	0	0	14	14	50,00%	50,00%	0,00%	0,00%	100,00%	100,00%
	25.	Are there any regulations for the grouting of the borehole heat exchanger?		Yes	No	No	No	Yes	No	Yes	No	No	Case to case decision	Yes	Yes	No	Yes		6	7	1	0	14	14	42,86%	50,00%	7,14%	0,00%	100,00%	100,00%
	26.	Is the flow test of the closed-loop and refrigerant tubing mandatory?		No		No	No	No	No	Yes	No	No	No	Yes	Yes		No		3	9	0	2	12	14	21,43%	64,29%	0,00%	14,29%	85,71%	100,00%
	27.	Is the tightness test of the closed-loop and refrigerant tubing mandatory?		Yes		No	No	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes		8	5	0	1	13	14	57,14%	35,71%	0,00%	7,14%	92,86%	100,00%
	28.	Is the borehole drilling report mandatory?		Yes	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		10	4	0	0	14	14	71,43%	28,57%	0,00%	0,00%	100,00%	100,00%
	29.	Is the sampling of the cuttings mandatory?		Case to case decision	No	No	No	No	No	No	No	No	No	Yes	Yes	No	Yes		3	10	1	0	14	14	21,43%	71,43%	7,14%	0,00%	100,00%	100,00%
	30.	Is the sampling of the drilling core mandatory?		No	No	No	No	No	No	No	No	No	No	Yes	No	No	No		1	13	0	0	14	14	7,14%	92,86%	0,00%	0,00%	100,00%	100,00%
	31.	Is the thermal response test (TRT) mandatory?		Case to case decision	No	No	No	No	No	Yes	No	No	No	No	Case to case decision	No	No		1	11	2	0	14	14	7,14%	78,57%	14,29%	0,00%	100,00%	100,00%
	32.	Is the exact measurement of the borehole depth mandatory?		No	No	No	No	Yes	No	Yes	No	Yes	No	Yes	Yes	No	Yes		6	8	0	0	14	14	42,86%	57,14%	0,00%	0,00%	100,00%	100,00%
	33.	Are the groundwater investigations (dynamics, hydrochemistry, etc.) mandatory?		No	No	No	No	Yes	No	Case to case decision	No	No	No	Yes	No	No	Case to case decision		2	10	2	0	14	14	14,29%	71,43%	14,29%	0,00%	100,00%	100,00%
	Subtotal 18.-33.																		**74**	**139**	**8**	**3**	**221**	**224**	**33,04%**	**62,05%**	**3,57%**	**1,34%**	**98,66%**	**100,00%**
	TOTAL 1.-33.																	**TOTAL**	**176**	**247**	**36**	**3**	**459**	**462**	**38,10%**	**53,46%**	**7,79%**	**0,65%**	**99,35%**	**100,00%**
			yes	20	9	6	2	19	2	18	10	10	10	32	16	8	14	**176**											
			no	6	21	27	29	14	31	12	21	20	19	1	7	21	18	**247**											
			case to case decision	7	1	0	2	0	0	3	2	3	4	0	10	3	1	**36**											
			no reply	0	2	0	0	0	0	0	0	0	0	0	0	1	0	**3**											
			total replies	33	31	33	33	33	33	33	33	33	33	33	33	32	33	**459**											
			total respondents	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**14**											

*total number of respondents is constant and equals 14, though, for calculations of percentage values in case of subtotal and total values the number of respondents was multiplied by a number of questions

Appendix IV Results of partners' questionnaire, part D, Regulation elements for SGES installation, implementation and operation

CLOSED-LOOP SYSTEMS (GSHP)	**18.**	Is the minimum distance (m) to the neighbouring ground plot defined?
	19.	Is the minimum distance (m) to the neighbouring buildings defined?
	20.	Is the minimum distance (m) to the neighbouring groundwater wells defined?
	21.	Is the minimum distance (m, % of well depth) between the borehole heat exchangers defined?
	22.	Is the target value for the average initial and input temperature (°C, K) of the heat carrier fluid defined?
	23.	Are there any specific regulations on the heat carrier fluid type?
	24.	Are there any specific regulations on the refrigerant type?
	25.	Are there any regulations for the grouting of the borehole heat exchanger?
	26.	Is the flow test of the closed-loop and refrigerant tubing mandatory?
	27.	Is the tightness test of the closed-loop and refrigerant tubing mandatory?
	28.	Is the borehole drilling report mandatory?
	29.	Is the sampling of the cuttings mandatory?
	30.	Is the sampling of the drilling core mandatory?
	31.	Is the thermal response test (TRT) mandatory?
	32.	Is the exact measurement of the borehole depth mandatory?
	33.	Are the groundwater investigations (dynamics, hydrochemistry, etc.) mandatory?
	Subtotal 18.-33.	
	TOTAL 1.-33.	

*total number of respondents is constant and equals 14, though, for calculations of percentage values in case of subtotal and total values the number of respondents was multiplied by a number of questions



Appendix V Results of partners' questionnaire, part E, Register and monitoring of SGE installations

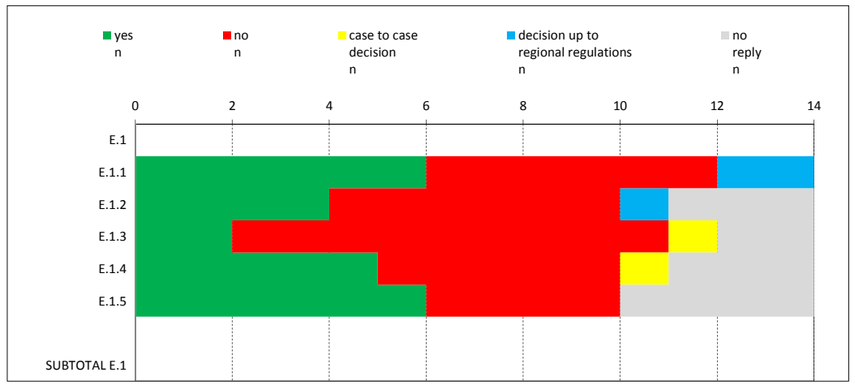
#	Question	P01 GBA AT	P02 NERC UK	P04 HGI-CGS HR	P05 CGS CZ	P06 BRGM FR	P07 GSI IE	P08 RBINS-GSB BE	P09 GeoZS SI	P10 IGME ES	P11 SGU SE	P12 TNO NL	P13 PIG-PIB PL	P14 SGIDS SK	P16 GEUS DK
E.1	**Comprehensive register of SGE installations / systems**														
E.1.1	Do you have in your country a register of SGE installations?	decision up to regional regulations	yes	no	no	yes	no	yes	no	no	yes	yes	no	decision up to regional regulations	yes
E.1.2	**If yes**, is it comprehensive and regularly updated?	no	yes	no		no	no	yes	no		yes	yes		no	decision up to regional regulations
E.1.3	**If yes**, is your GSO involved in running the register?	no	no	no	no	yes	no	case to case decision	no		yes	no		no	no
E.1.4	**If yes**, is the register publically available?	yes	no	no		yes	case to case decision	yes	yes		yes	no		no	no
E.1.5	**If no**, is the lack of the register a barrier for development of SGE market?	yes		no	yes		yes		yes	yes		no	no	yes	no
SUBTOTAL E.1	**SUBTOTAL 1**														

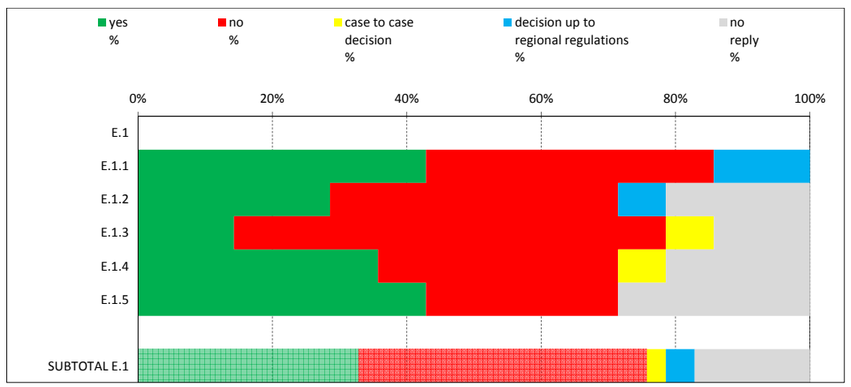
Appendix V Results of partners' questionnaire, part E, Register and monitoring of SGE installations

#	Question	yes n	no n	case to case decision n	decision up to regional regulations n	no reply n	total replies n	total respondents* n	yes %	no %	case to case decision %	decision up to regional regulations %	no reply %	total replies %	total respondents* %
E.1	**Comprehensive register of SGE installations / systems**														
E.1.1	Do you have in your country a register of SGE installations?	6	6	0	2	0	14	14	42,86%	42,86%	0,00%	14,29%	0,00%	100,00%	100,00%
E.1.2	**If yes**, is it comprehensive and regularly updated?	4	6	0	1	3	11	14	28,57%	42,86%	0,00%	7,14%	21,43%	78,57%	100,00%
E.1.3	**If yes**, is your GSO involved in running the register?	2	9	1	0	2	12	14	14,29%	64,29%	7,14%	0,00%	14,29%	85,71%	100,00%
E.1.4	**If yes**, is the register publically available?	5	5	1	0	3	11	14	35,71%	35,71%	7,14%	0,00%	21,43%	78,57%	100,00%
E.1.5	**If no**, is the lack of the register a barrier for development of SGE market?	6	4	0	0	4	10	14	42,86%	28,57%	0,00%	0,00%	28,57%	71,43%	100,00%
SUBTOTAL E.1	**SUBTOTAL 1**	**23**	**30**	**2**	**3**	**12**	**58**	**70**	**32,86%**	**42,86%**	**2,86%**	**4,29%**	**17,14%**	**82,86%**	**100,00%**

Appendix V Results of partners' questionnaire, part E, Register and monitoring of SGE installations

#	Question
E.1	**Comprehensive register of SGE installations / systems**
E.1.1	Do you have in your country a register of SGE installations?
E.1.2	**If yes**, is it comprehensive and regularly updated?
E.1.3	**If yes**, is your GSO involved in running the register?
E.1.4	**If yes**, is the register publically available?
E.1.5	**If no**, is the lack of the register a barrier for development of SGE market?
SUBTOTAL E.1	**SUBTOTAL 1**





Appendix V Results of partners' questionnaire, part E, Register and monitoring of SGE installations

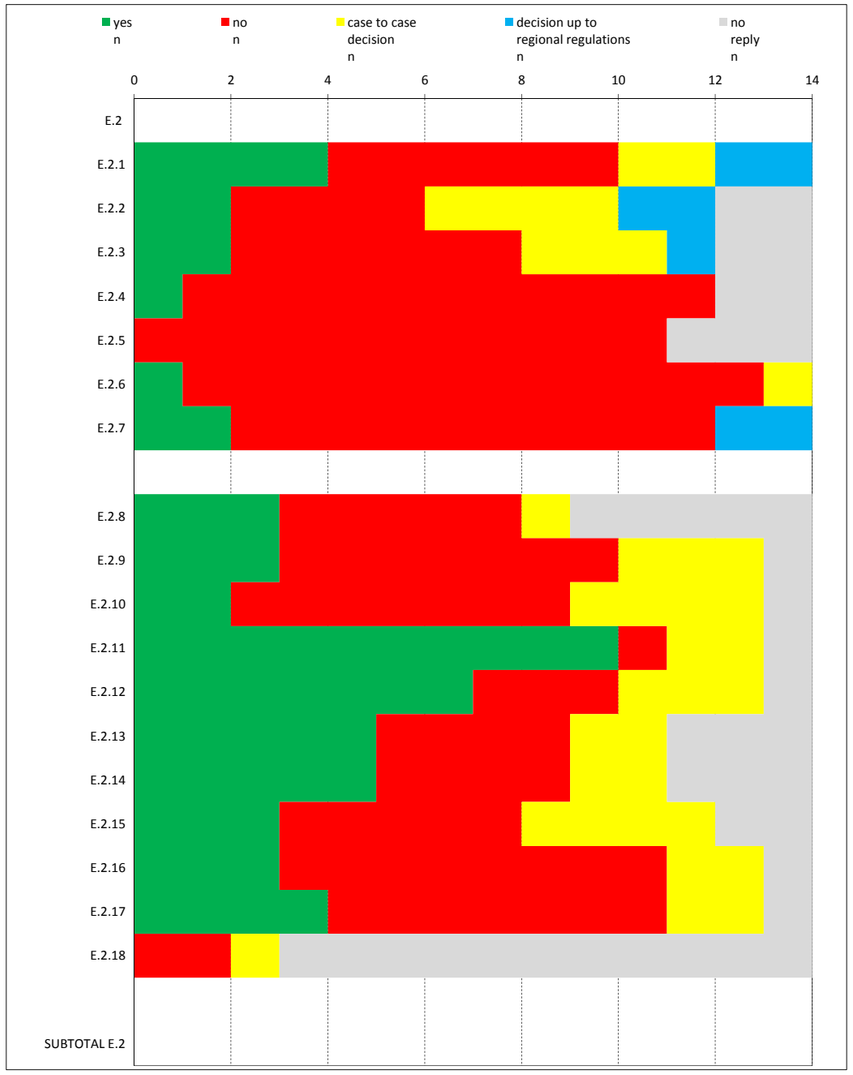
E.2	Monitoring of SGE installations / systems	P01 GBA AT	P02 NERC UK	P04 HGI-CGS HR	P05 CGS CZ	P06 BRGM FR	P07 GSI IE	P08 RBINS-GSB BE	P09 GeoZS SI	P10 IGME ES	P11 SGU SE	P12 TNO NL	P13 PIG-PIB PL	P14 SGIDS SK	P16 GEUS DK
E.2.1	Is monitoring of SGE installations (system efficiency and/or environmental) compulsory in your country?	decision up to regional regulations	case to case decision	no	no	no	no	yes	case to case decision	yes	no	yes	no	decision up to regional regulations	yes
E.2.2	**If yes,** do the authorities enforce monitoring?	decision up to regional regulations	case to case decision	no	no		no	case to case decision	case to case decision	yes	case to case decision	yes		decision up to regional regulations	no
E.2.3	**If yes**, is monitoring applied to all installations independently of the installed capacity or only to large capacity installations? If yes, what is the minimum capacity for obligatory monitoring (write the threshold value in comments)?	decision up to regional regulations	case to case decision	no	no		no	yes	no	yes	case to case decision	no		no	case to case decision
E.2.4	**If yes**, do the authorities run a general digital database in which the monitoring data of the individual installations is stored?	no	no	no	no		no	no	no	yes	no	no		no	no
E.2.5	**If yes,** are the monitoring results of the public buildings publically available?	no	no	no	no		no	no	no	no	no	no		no	
E.2.6	**If yes,** is your GSO involved in monitoring of SGE installations?	case to case decision	yes	no	no	no	no	no	no	no	no	no	no	no	no
E.2.7	**If yes,** are there any recommendations on monitoring of efficiency of SGE installations available?	decision up to regional regulations	no	no	decision up to regional regulations	yes	no	no	no	no	no	no	no	no	yes
	If yes, which parameters are monitored:														
E.2.8	*Heating/cooling installed capacity*	no	yes				no	no	no	yes		yes	case to case decision	no	
E.2.9	*Operating hours*	no	yes	case to case decision	no	yes	no	no	no	no		yes	case to case decision	no	case to case decision
E.2.10	*Electricity consumption*	no	yes	case to case decision	no	case to case decision	no	no	no	no		yes	case to case decision	no	case to case decision
E.2.11	*Water extraction volume*	yes	yes	yes	yes	yes	no	yes	case to case decision	yes		yes	case to case decision	yes	yes
E.2.12	*Water injection volume*	yes	yes	yes	no	yes	no	yes	no	yes		yes	case to case decision	case to case decision	case to case decision
E.2.13	*Temperature of extracted water*	yes	yes	no	no		no	yes	no	yes		yes	case to case decision	case to case decision	
E.2.14	*Temperature of injected water*	yes	yes	no	no		no	yes	no	yes		yes	case to case decision	case to case decision	
E.2.15	*Ground temperature*	no		no	no	case to case decision	no	case to case decision	case to case decision	no		yes	case to case decision	yes	yes
E.2.16	*Heating/cooling medium temperature*	no	yes	no	no	case to case decision	no	no	no	no		yes	yes	no	case to case decision
E.2.17	*Thermal energy production*	no	yes	no	no	yes	no	no	no	yes		yes	case to case decision	no	case to case decision
E.2.18	*Other*			no	no										case to case decision
SUBTOTAL E.2															

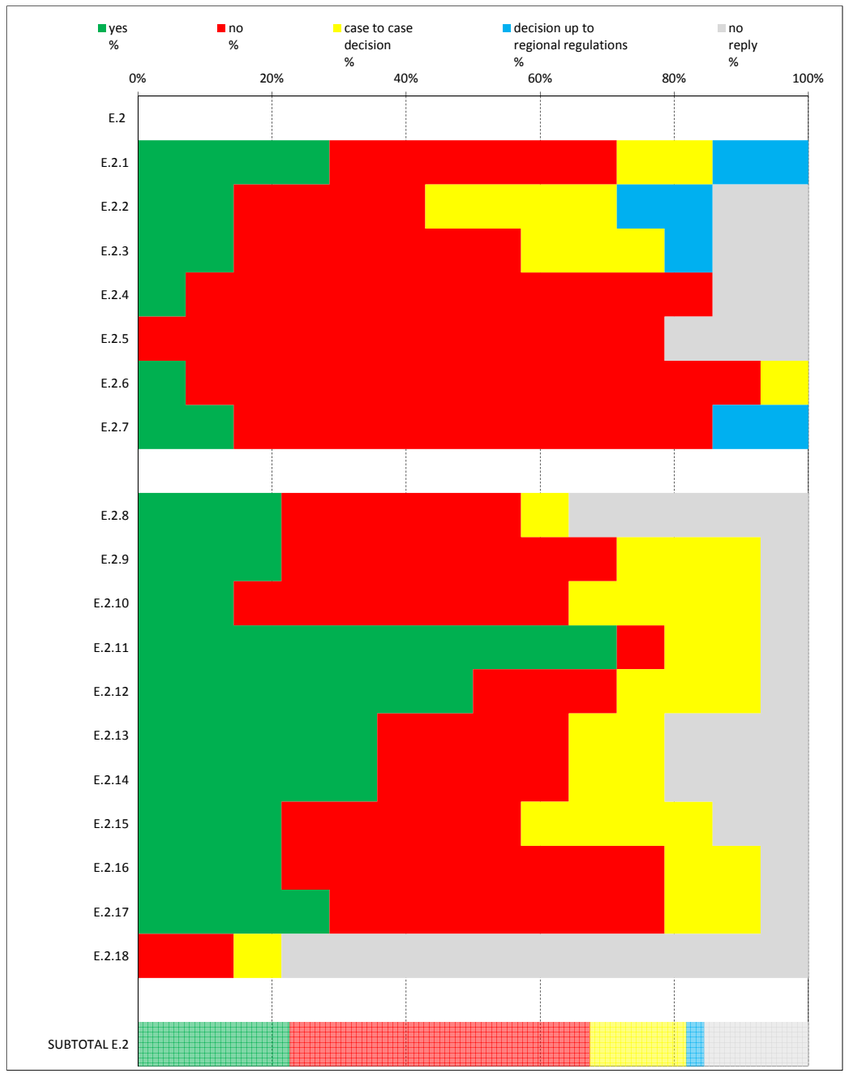
Appendix V Results of partners' questionnaire, part E, Register and monitoring of SGE installations

E.2	Monitoring of SGE installations / systems	yes n	no n	case to case decision n	decision up to regional regulations n	no reply n	total replies n	total respondents* n	yes %	no %	case to case decision %	decision up to regional regulations %	no reply %	total replies %	total respondents* %
E.2.1	Is monitoring of SGE installations (system efficiency and/or environmental) compulsory in your country?	4	6	2	2	0	14	14	28,57%	42,86%	14,29%	14,29%	0,00%	100,00%	100,00%
E.2.2	**If yes,** do the authorities enforce monitoring?	2	4	4	2	2	12	14	14,29%	28,57%	28,57%	14,29%	14,29%	85,71%	100,00%
E.2.3	**If yes**, is monitoring applied to all installations independently of the installed capacity or only to large capacity installations? If yes, what is the minimum capacity for obligatory monitoring (write the threshold value in comments)?	2	6	3	1	2	12	14	14,29%	42,86%	21,43%	7,14%	14,29%	85,71%	100,00%
E.2.4	**If yes**, do the authorities run a general digital database in which the monitoring data of the individual installations is stored?	1	11	0	0	2	12	14	7,14%	78,57%	0,00%	0,00%	14,29%	85,71%	100,00%
E.2.5	**If yes,** are the monitoring results of the public buildings publically available?	0	11	0	0	3	11	14	0,00%	78,57%	0,00%	0,00%	21,43%	78,57%	100,00%
E.2.6	**If yes,** is your GSO involved in monitoring of SGE installations?	1	12	1	0	0	14	14	7,14%	85,71%	7,14%	0,00%	0,00%	100,00%	100,00%
E.2.7	**If yes,** are there any recommendations on monitoring of efficiency of SGE installations available?	2	10	0	2	0	14	14	14,29%	71,43%	0,00%	14,29%	0,00%	100,00%	100,00%
	If yes, which parameters are monitored:														
E.2.8	*Heating/cooling installed capacity*	3	5	1	0	5	9	14	21,43%	35,71%	7,14%	0,00%	35,71%	64,29%	100,00%
E.2.9	*Operating hours*	3	7	3	0	1	13	14	21,43%	50,00%	21,43%	0,00%	7,14%	92,86%	100,00%
E.2.10	*Electricity consumption*	2	7	4	0	1	13	14	14,29%	50,00%	28,57%	0,00%	7,14%	92,86%	100,00%
E.2.11	*Water extraction volume*	10	1	2	0	1	13	14	71,43%	7,14%	14,29%	0,00%	7,14%	92,86%	100,00%
E.2.12	*Water injection volume*	7	3	3	0	1	13	14	50,00%	21,43%	21,43%	0,00%	7,14%	92,86%	100,00%
E.2.13	*Temperature of extracted water*	5	4	2	0	3	11	14	35,71%	28,57%	14,29%	0,00%	21,43%	78,57%	100,00%
E.2.14	*Temperature of injected water*	5	4	2	0	3	11	14	35,71%	28,57%	14,29%	0,00%	21,43%	78,57%	100,00%
E.2.15	*Ground temperature*	3	5	4	0	2	12	14	21,43%	35,71%	28,57%	0,00%	14,29%	85,71%	100,00%
E.2.16	*Heating/cooling medium temperature*	3	8	2	0	1	13	14	21,43%	57,14%	14,29%	0,00%	7,14%	92,86%	100,00%
E.2.17	*Thermal energy production*	4	7	2	0	1	13	14	28,57%	50,00%	14,29%	0,00%	7,14%	92,86%	100,00%
E.2.18	*Other*	0	2	1	0	11	3	14	0,00%	14,29%	7,14%	0,00%	78,57%	21,43%	100,00%
SUBTOTAL E.2		**57**	**113**	**36**	**7**	**39**	**213**	**252**	**22,62%**	**44,84%**	**14,29%**	**2,78%**	**15,48%**	**84,52%**	**100,00%**

Appendix V Results of partners' questionnaire, part E, Register and monitoring of SGE installations

E.2	Monitoring of SGE installations / systems
E.2.1	Is monitoring of SGE installations (system efficiency and/or environmental) compulsory in your country?
E.2.2	**If yes,** do the authorities enforce monitoring?
E.2.3	**If yes**, is monitoring applied to all installations independently of the installed capacity or only to large capacity installations? If yes, what is the minimum capacity for obligatory monitoring (write the threshold value in comments)?
E.2.4	**If yes,** do the authorities run a general digital database in which the monitoring data of the individual installations is stored?
E.2.5	**If yes,** are the monitoring results of the public buildings publically available?
E.2.6	**If yes,** is your GSO involved in monitoring of SGE installations?
E.2.7	**If yes,** are there any recommendations on monitoring of efficiency of SGE installations available?
	If yes, which parameters are monitored:
E.2.8	*Heating/cooling installed capacity*
E.2.9	*Operating hours*
E.2.10	*Electricity consumption*
E.2.11	*Water extraction volume*
E.2.12	*Water injection volume*
E.2.13	*Temperature of extracted water*
E.2.14	*Temperature of injected water*
E.2.15	*Ground temperature*
E.2.16	*Heating/cooling medium temperature*
E.2.17	*Thermal energy production*
E.2.18	*Other*
SUBTOTAL E.2	





Appendix V Results of partners' questionnaire, part E, Register and monitoring of SGE installations

	Environmental monitoring of SGE installations	P01 GBA AT	P02 NERC UK	P04 HGI-CGS HR	P05 CGS CZ	P06 BRGM FR	P07 GSI IE	P08 RBINS-GSB BE	P09 GeoZS SI	P10 IGME ES	P11 SGU SE	P12 TNO NL	P13 PIG-PIB PL	P14 SGIDS SK	P16 GEUS DK
E.3	Are there any **recommendations** on environmental monitoring related to SGE installations (during all phases, e.g.: construction, operation)?	Yes	Yes	no	no	yes	case to case decision	yes	yes	no	case to case decision	Yes	no	no	case to case decision
E.3.1	**If yes,** is environmental monitoring **required** in relation to SGE construction phase (e.g.: drilling, testing, etc.)?	no	yes	case to case decision		yes	no	yes	case to case decision	no	case to case decision	yes	case to case decision	no	yes
E.3.2	**If yes,** is your GSO involved in environmental monitoring of SGE installations?	yes	case to case decision	case to case decision		no	no	no	case to case decision	case to case decision	no	no	no	no	no
E.3.3	**If yes,** is installation of monitoring wells and/or piezometers for environmental monitoring of SGE installations required?	yes		no	no	no	no	no	case to case decision	decision up to regional regulations	case to case decision	yes	case to case decision	no	case to case decision
E.3.4	**If yes**, which parameters are monitored:														
E.3.5	*Groundwater head*	yes	case to case decision	no	no		no	yes	case to case decision	yes	yes	yes	yes	no	yes
E.3.6	*Groundwater temperature*	yes	case to case decision	yes	no		no	yes	case to case decision	yes	yes	yes	case to case decision	no	yes
E.3.7	*Physiochemical parameters of groundwater, e.g.: EC, TDS, pH, Eh, O2 conc., etc.*	yes	case to case decision	yes	no		no	no	case to case decision	yes	no	yes	case to case decision	no	case to case decision
E.3.8	*Chemical composition of groundwater*	yes	case to case decision	yes	no		no	no	case to case decision	yes	case to case decision	yes	case to case decision	no	case to case decision
E.3.9	*Contamination of groundwater, rocks and soils*	no	case to case decision	no	no		no	yes	case to case decision	no	no	yes	case to case decision	no	case to case decision
E.3.10	*Microbiota in groundwater, rocks and soils*	no	case to case decision	no	no		no	no	case to case decision	no	no	yes		no	case to case decision
E.3.11	*Other*			no	no			yes			no				
SUBTOTAL E.3															
TOTAL E.1 - E.3															
	TOTAL														
	yes n	13	14	5	2	10	1	15	3	15	6	23	2	3	8
	no n	13	5	24	26	5	29	14	16	12	10	9	7	23	7
	case to case decision n	1	10	4	0	3	2	3	13	1	6	0	15	3	13
	decision up to regional regulations n	5	0	0	1	0	0	0	0	1	0	0	0	3	1
	no reply n	2	5	1	5	16	2	2	2	5	12	2	10	2	5
	total replies n	32	29	33	29	18	32	32	32	29	22	32	24	32	29
	total respondents* n	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Appendix V Results of partners' questionnaire, part E, Register and monitoring of SGE installations

	Environmental monitoring of SGE installations	yes n	no n	case to case decision n	decision up to regional regulations n	no reply n	total replies n	total respondents* n	yes %	no %	case to case decision %	decision up to regional regulations %	no reply %	total replies %	total respondents* %
E.3	Are there any **recommendations** on environmental monitoring related to SGE installations (during all phases, e.g.: construction, operation)?	6	5	3	0	0	14	14	42,86%	35,71%	21,43%	0,00%	0,00%	100,00%	100,00%
E.3.1	**If yes,** is environmental monitoring **required** in relation to SGE construction phase (e.g.: drilling, testing, etc.)?	5	4	4	0	1	13	14	35,71%	28,57%	28,57%	0,00%	7,14%	92,86%	100,00%
E.3.2	**If yes,** is your GSO involved in environmental monitoring of SGE installations?	1	8	4	0	1	13	14	7,14%	57,14%	28,57%	0,00%	7,14%	92,86%	100,00%
E.3.3	**If yes,** is installation of monitoring wells and/or piezometers for environmental monitoring of SGE installations required?	2	6	4	1	1	13	14	14,29%	42,86%	28,57%	7,14%	7,14%	92,86%	100,00%
E.3.4	**If yes**, which parameters are monitored:	0	0	0	0	14	0	14	0,00%	0,00%	0,00%	0,00%	100,00%	0,00%	100,00%
E.3.5	*Groundwater head*	7	4	2	0	1	13	14	50,00%	28,57%	14,29%	0,00%	7,14%	92,86%	100,00%
E.3.6	*Groundwater temperature*	7	3	3	0	1	13	14	50,00%	21,43%	21,43%	0,00%	7,14%	92,86%	100,00%
E.3.7	*Physiochemical parameters of groundwater, e.g.: EC, TDS, pH, Eh, O2 conc., etc.*	4	5	4	0	1	13	14	28,57%	35,71%	28,57%	0,00%	7,14%	92,86%	100,00%
E.3.8	*Chemical composition of groundwater*	4	4	5	0	1	13	14	28,57%	28,57%	35,71%	0,00%	7,14%	92,86%	100,00%
E.3.9	*Contamination of groundwater, rocks and soils*	2	7	4	0	1	13	14	14,29%	50,00%	28,57%	0,00%	7,14%	92,86%	100,00%
E.3.10	*Microbiota in groundwater, rocks and soils*	1	8	3	0	2	12	14	7,14%	57,14%	21,43%	0,00%	14,29%	85,71%	100,00%
E.3.11	*Other*	1	3	0	0	10	4	14	7,14%	21,43%	0,00%	0,00%	71,43%	28,57%	100,00%
SUBTOTAL E.3		**40**	**57**	**36**	**1**	**34**	**134**	**168**	**23,81%**	**33,93%**	**21,43%**	**0,60%**	**20,24%**	**79,76%**	**100,00%**
TOTAL E.1 - E.3	**TOTAL**	**120**	**200**	**74**	**11**	**85**	**405**	**490**	**24,49%**	**40,82%**	**15,10%**	**2,24%**	**17,35%**	**82,65%**	**100,00%**

120
200
74
11
71
405
14

Appendix V Results of partners' questionnaire, part E, Register and monitoring of SGE installations

	Environmental monitoring of SGE installations
E.3	Are there any **recommendations** on environmental monitoring related to SGE installations (during all phases, e.g.: construction, operation)?
E.3.1	**If yes,** is environmental monitoring **required** in relation to SGE construction phase (e.g.: drilling, testing, etc.)?
E.3.2	**If yes,** is your GSO involved in environmental monitoring of SGE installations?
E.3.3	**If yes,** is installation of monitoring wells and/or piezometers for environmental monitoring of SGE installations required?
E.3.4	**If yes**, which parameters are monitored:
E.3.5	*Groundwater head*
E.3.6	*Groundwater temperature*
E.3.7	*Physiochemical parameters of groundwater, e.g.: EC, TDS, pH, Eh, O2 conc., etc.*
E.3.8	*Chemical composition of groundwater*
E.3.9	*Contamination of groundwater, rocks and soils*
E.3.10	*Microbiota in groundwater, rocks and soils*
E.3.11	*Other*
SUBTOTAL E.3	
TOTAL E.1 - E.3