GeoPLASMA-CE: Assessment of methods for conflict mapping

Deliverable D.T2.2.3: Synopsis of mapping methods of land-use conflicts and environmental impact assessment

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Content

Glossary

	description
Geothermal energy	Energy stored below the surface of the solid earth in the form of heat
Shallow geothermal use	The use of geothermal energy until a depth of 400 m
geothermal potential	The useful accessible resource — that part of geothermal energy of a given area that could be extracted economically and legally at some specified time in the future
Risk and land-use conflicts	direct or indirect negative impact on the environment which geothermal exploitation affects to the compartments (water, soil, air, nature) and on other land uses nearby
3D structural model	describes the geometry, spatial distribution and neighborhood relationship of geological units in the modelling domain
Suitability	The possibility to use shallow geothermal energy by a specific method
Parameter model	Assigns physical or chemical parameters to the geological units specified in the 3D structural model. It can be used for calculations or predictions.
COP	The coefficient of performance of an electric heat pump for a certain working point is the momentary ratio of the thermal output emitted to the consumed electrical power.
Map	is a projection of a high-dimensional object on a plane. Usually, it is a scaled, simplified and generalized model of the earth.
Geothermal mapping	Calculation and visualisation of geothermal potential by specific thematic output parameters (e.g. thermal conductivity, extraction rates)
Conflict mapping	Calculation and visualisation of land-use conflicts and risk areas due to geothermal utilisation (e.g. traffic light maps, specific conflict layers)
Metadata	Provides information about the data itself. It summarizes basic properties of the data and makes working with the data easier. E.g. metadata of a book are its author and year of publication.
Closed loop system	(borehole heat exchanger) In a closed loop system the heat carrier fluid is not transferred in or out of the system boundaries, only heat is exchanged. They are vertically or inclined installed in the underground. Mostly these are U-shaped plastic pipes installed in boreholes, or arranged concentrically as an inner or outer pipe. Heat transport within the borehole heat exchangers takes place mostly through the pumping of a working fluid.
Open loop system	In an open loop system, the heat carrier fluid is groundwater. It is withdrawn from an extraction well, passes through a heat exchanger and a heat pump, if necessary, afterwards it is returned to the

	aquifer via the injection well.
Extraction well	Withdraws groundwater from an aquifer. It consists of a plastic filter tube, which is implemented in a borehole. It is part of a geothermal application using groundwater as heat source.
Injection well:	Is the second well - aside from the extraction well – needed for a geothermal application using groundwater as heat source. A well through which geothermal water is returned to an underground reservoir after use. Geothermal production and injection wells are constructed of pipes layered inside one another and cemented into the earth and to each other.
Hydraulic conductivity	Quantifies the capacity of rock and unconsolidated sediments to transmit a fluid, taking density and viscosity of the fluid into account. The unit is [m/s].
Aquifer	a large permeable body of underground rock capable of yielding quantities of water to springs or wells.
Geothermal gradient	the rate of temperature increase in the Earth as a function of depth.
Geothermal heat pumps	devices that take advantage of the relatively constant temperature of the Earth's subsurface, using it as a source and sink of heat for both heating and cooling. In cooling mode heat is dissipated into the Earth; when heating, heat is extracted from the Earth resulting in a temporary temperature decrease in the underground surrounded by the application.
Permeability:	capacity of a substance (such as rock) to transmit a fluid. The degree of permeability depends on the number, size, and shape of the pores and/or fractures in the rock and their interconnections. It is measured by the time it takes a fluid of standard viscosity to move a given distance. The unit of permeability is Darcy [m^2].
Porosity:	ratio of the aggregate volume of pore spaces in rock or soil to its total volume, usually stated as a percentage.

1. Introduction

The aim of the GeoPLASMA-CE project is to develop new management strategies for shallow geothermal use of urban and non-urban regions. The project intends to create a standardized data base and a web-based platform including the geothermal potential as well as factors of risk and land-use conflicts. The data comprises geological and structural data, petrophysical and technical parameters as well as the model data produced during different stages of the project. The geothermal potential modelling and the risk-factor validation will be based on a 3D structural model of the shallow geological subsurface which will be used to quantify the spatial distribution of physical and technical parameters and of risk factors.

To elaborate a compilation and assessment of existing methods a literature study was conducted as first step to establish a workflow for geothermal modelling in GeoPLASMA-CE. Information about existing methods for geothermal mapping of current and previous projects for 3D-modelling, open loop and closed loop systems as well as land-use-conflict mapping was gathered. The applicability of the methods used in the projects for GeoPLASMA-CE was investigated in a next step. The project team created a template to summarize the most important information about the methods regarding the topics mentioned (3D-modelling, open loop and closed loop systems, land-use-conflict mapping). Summaries of all methods and lessons learned from the projects, which provide important inputs, were established for four separate reports, based on these standardized assessment sheets:

- Synopsis of geological 3D-modelling methods,
- Synopsis of geothermal mapping methods - open loop systems,
- Synopsis of geothermal mapping methods - closed loop systems,
- Synopsis of mapping methods of land-use conflicts and environmental impact assessment.

All assessment sheets are added in annex 1 for further information. The publications concerning the analysed projects were collected and are available for further research and use in the database “knowledge repository”.

This process generated important knowledge about how to develop workflows of geothermal mapping for GeoPLASMA-CE, which will be accomplished within the next steps.

The delivered four reports and the knowledge repository will be available online at the project’s website (http://www.interreg-central.eu/Content.Node/GeoPLASMA-CE.html).

2. General workflow for geothermal mapping based on a 3D model

The first step of all is to build a geological 3D model related to geothermal and hydrogeological issues as a basis for the thematic geothermal mapping and land-use conflict mapping. In general, all workflows for mapping the geothermal potential have to follow one scheme (figure 1):

The modelling has to include geometric and physical data, these data have to be interpreted and prepared according to the projects' objectives. Then, the spatial distribution of the physical parameters has to be modelled. This includes the major step of generating a structural model of the subsurface.

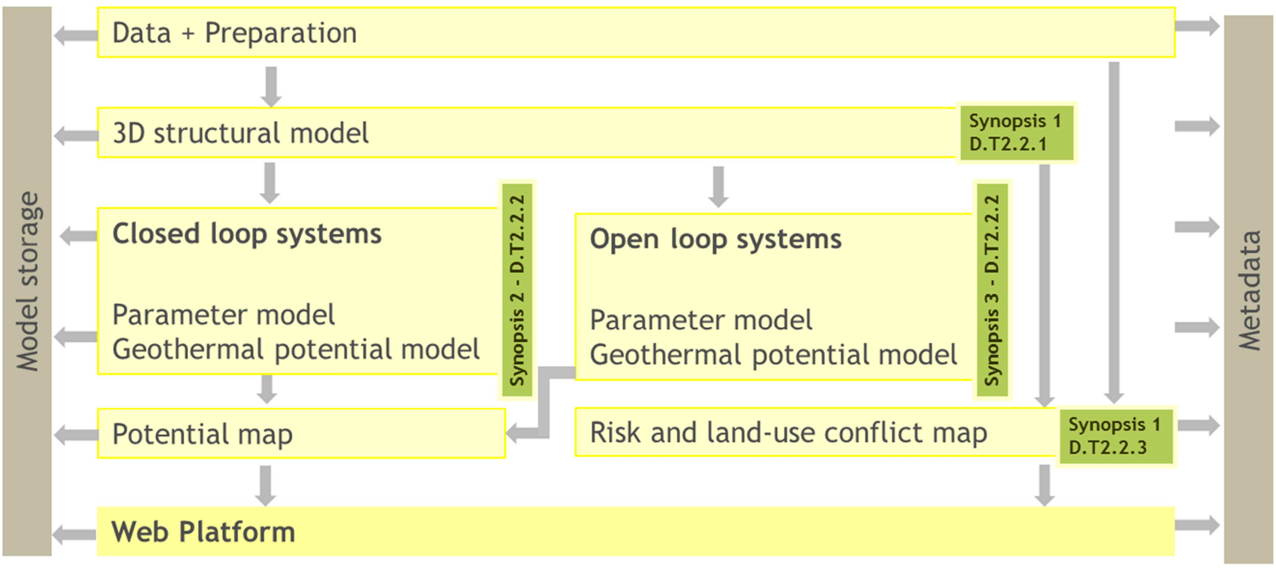

Figure 1: Workflow for modelling the geothermal potential of a region.

A structural model has to be parameterized with the physical parameters needed to solve the equations describing the geothermal potential. Then, the geothermal potential is calculated. The geothermal potentials for open loop and closed loop systems will be determined separately for GeoPLASMA-CE. The outputs of the potential modelling are divided into suitability or value classes and visualized within a next step, in order to ensure an easy handling for the stakeholders. This result has to be visualized for the stakeholders of the model.

For the risk and land-use conflict maps some additional information is necessary, which cannot all be extracted from the structural model, i.e. the location of groundwater protection zones or natural reserves. This information has to be included into the steps of thematic map production. If the thematic maps shall be displayed on a screen, a conversion of the 3D modelling results into 2D potential maps is necessary. The maps will be displayed on a web-platform with specific visualization and query functions. All input data used to develop the models will be stored at the project partners independently. However, all information, which will be provided later on the web-portal, will be organized in a joint database for all project partners.

3. Conflict mapping for geothermal systems

This synopsis gives an overview of existing methods for land-use-conflict and vulnerability mapping, in this text abbreviated as “conflict mapping”, achieved in previous and ongoing projects. It also contains an overview of potential land use conflicts and environmental impacts. Figure 2 shows an overview of the main categories of vulnerabilities and land-use conflicts and some examples concerning geothermal uses after categorisation of Ad-hoc-AG Geologie, PK Geothermie (2011) (Nr. 60).

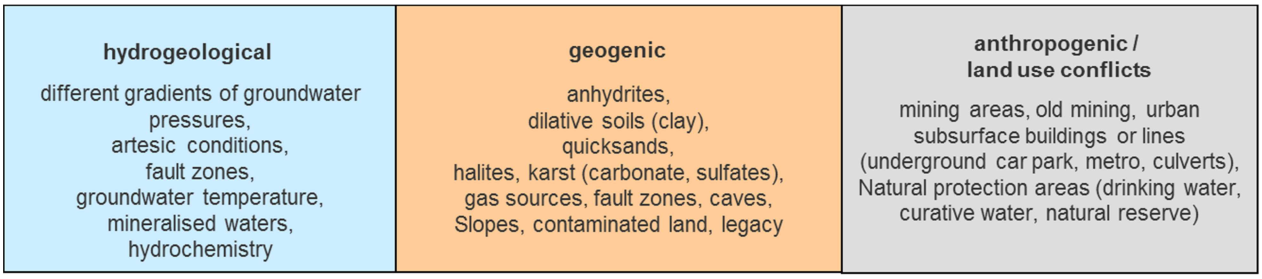

Figure 2: Main vulnerabilities/land use conflicts for geothermal usages.

3.1. Research of existing conflict mapping methods

All project partners sent papers and forms on projects from the participating countries. Furthermore web-based portals on shallow geothermal energy were investigated on whether they contain information about land use conflict and risk factors. Eight geothermal portals presenting these factors were found:

Table 1: screened projects with relevance for conflict mapping of geothermal systems

Country, project	ID knowledge repository
ISONG (Informationssystem für oberflächennahe Geothermie) Baden-Württemberg	26
IOG (Informationssystem oberflächennahe Geothermie) Bavaria	54
Geothermieportal NRW	61
Portal Geothermie Rheinland-Pfalz	56
GeotIS (geothermal information system) Germany	25
NIBIS (Niedersächsischer Bildungsserver) Niedersachsen	55
Salzburg	22
Ad-hoc-AG Geologie, PK Geothermie	60

None of the web portals on geothermal energy contains an explicit section “risk factors and land-use conflict”. Instead, the risk factors are presented in a mixed context with the geothermal potential or other maps like geological or hydrogeological maps.

Factors of risk and land-use conflict can be presented either in a geoscientific none interpreted or in an interpreted way. In some portals, both forms are mixed:

- GeotIS (Nr. 25) provides only none interpreted geoscientific maps of risk factors like faults and salt structures.
- ISONG (Nr. 26) provides only interpreted risk and conflict maps. E.G. the map "water protection zones" contains categories "building of heat pumps is not possible – possible to a limited depth – permitted – needs approval". Additionally, a map with limitations of drilling depths and a map with regions of artesic groundwater are available.
- IOG (Nr. 54), Portal Geothermie (Nr. 56) and NIBIS (Nr. 55) contain a mixed set of interpreted and none interpreted, purely geoscientific information. These three web platforms contain "traffic-light maps", with three categories "possible" –"approval necessary, individual check" – "generally possible". These maps give a very short overview, but do not offer an explanation. Additionally, interpreted maps on aquifer yield, the suitability of soils for heat collectors, artesic and confined groundwater are available. Sets of none interpreted maps show geological units and soil, the depth of groundwater tables, regions with sinkholes, mining, sulphate rocks and salt and water protection zones. No interpretation is given.
- NIBIS (Nr. 55) contains a map with a compilation of land use conflict and risk factors plus a validation of these risk factors for geothermal applications.

The research of all projects shows different possible presentations of nearly the same information. The main information provided by land use conflict mapping according to geothermal uses is:

1. ***Suitability map of geothermal system*** → to get information if none, one or both geothermal systems (open and closed loop) at a certain location are possible or not,
2. ***Traffic light maps*** → to get information if the chosen geothermal system is generally possible, restricted (individual check) or not possible at a certain location,
3. ***Information about land use conflicts*** → specific thematic information layers about existing land use risks/conflicts that are provided for expert users only in the projects investigated (e.g. specific geological units, protection areas, and subsurface lines).

Mapping workflows, necessary input data and possible visualisations of these three types of maps are explained in the next chapters.

3.2. Input data

The first step to get information about possible land use conflicts is to develop a data inventory of the defined pilot areas. For GeoPLASMA-CE project a parameter list of each pilot area is developed at thematic work package (WPT) 3. With this data inventory and the geological 3D-model a base for assessment of the conflict areas is given. In addition to the geological 3D information, according the distribution area and thickness of geological units, input parameter for land-use conflict mapping as a base for any web decision application or traffic light maps are shown in table 1.

Table 2: main parameters for possible conflict layers

parameter
location of natural springs (harmonized coordinate system)
location of thermal springs (harmonized coordinate system)
protected areas for drinking water
protected areas for curative water
groundwater protection zones
protected areas for floodplains

protected areas for natural reserve
outline of cavity areas (natural)
outline of mining areas, undermined areas, cavity
raw material production areas
hydrogeological maps: outline of aquifers, hydrostratigraphical units
full geological 3D-model
outline of swellable rocks
outline of karst formations
risk areas for landslides
risk areas for shallow gas leackage
groundwater thickness maps
outline of confined, artesian groundwater bodies
hydrochemical information: Outline of groundwater bodies with problematic chemistry (scaling, corrosion, anthropogenic contamination)
groundwater hydrograph, groundwater recharge rate
tectonics - planes, foliation
subsurface lines (gas, electric power, water, telephone)

3.3. Data processing and modelled objects

Concerning the catalogue of requirements there are two main stakeholder groups with different needs and necessary mapping outputs:

Table 3: main outputs for conflict mapping

outputs	public user	expert user
map of suitable geothermal system	☺	☺
Traffic light map	☺	☺
layers of specific land use risks and conflicts		☺

To get a general overview if and which geothermal system is applicable for a specific location the suitability maps are useful for public and expert users. There is a direct link between the traffic light maps and the suitability maps. For detailed information of planning the geothermal system the specific geological, hydrogeological and technical informations of possible conflicts are relevant for expert users.

To develop the traffic-light maps and the specific conflict layers the input data (e.g. table 1) have to be processed, interpreted and reclassified into new layer (mostly via buffering or specific data selection).

3.3.1. Suitability map of geothermal systems

In order to get any information about the suitability and possibility of geothermal systems like closed or open loop systems, the 3D model of geological and hydrogeological conditions have to be developed first.

To give advices for a special geothermal system, the (hydro)geological data have to be interpreted for these two usages.

The approach to develop these maps should be harmonized, the individual interpretation if a geothermal system is possible or not is also depending on legal restrictions and has to be defined separately for each pilot area/country in GeoPLASMA-CE.

Situations and rules based of the project IOG, Bavaria (Nr. 54) of the four possible outputs are shown at table 3. Only a closed loop system is possible or recommended, if no or little groundwater is available, like in hard rock areas or areas with aquitard or aquiclude geologic units and no conflict areas are present.

All areas that contain usable groundwater body, which is not protected and that have no derived conflict/land use risk areas are possible for both systems (closed + open loop).

If these conditions of an unprotected usable groundwater body and an additional drilling limitation of the 1th aquifer in a low depth until ~ 40 m exist, and the aquifer shows a good hydrochemical behaviour and high transmissivity, a closed loop system is not applicable and not recommended. So these areas could be recommended only for open loop systems like at IOG (Bavaria).

The last output “no usage possible” occurs if the location is at areas with conflict zones, which forbid any drilling for geothermal usage (category red at traffic light map). These zones have to be defined during the specific conflict mapping and are summarized as red category for the traffic light map (see chapter 3.3.2).

Table 4: examples of defining situations for geothermal systems

situation	recommended/suitable geothermal system
no groundwater available	closed loop system
groundwater available	closed + open loop systems
Drilling limitation of 1th aquifer (< 40 m) Good groundwater conditions	open loop system recommended
Water protection areas	no usage possible

3.3.2. Traffic light maps

With a traffic light map a public and expert user get a short and efficient overview if a geothermal system is generally possible and allowed or not. Figure 3 shows the principal legend of a traffic light map for geothermal systems. In red areas a geothermal usage is not possible, in yellow areas the geothermal usage is general possible but combined with a necessary individual check and in green areas the geothermal usage is generally possible.

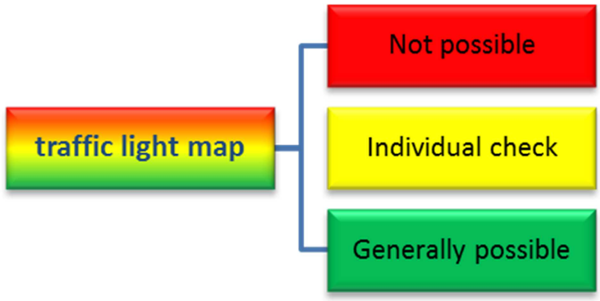

Figure 3: Legend of geothermal traffic light maps.

The input data have to be defined for a system of rules that influence the relevance of the location assessment. The processed GIS-data, it´s spreading (as e.g. shape) and it´s rule define a conflict information layer. The attributes of the conflict layer has following information included:

- Name of conflict layer, representing the GIS-dataset,
- Name of conflict layer, representing the spreading of the equivalent GIS-dataset,
- Rule for interpretation in form of a report (visualization of additional information),
- Listing of polygon attributes, that should be added to the report (Whitelist),
- Rule to apply the layer at traffic light map: point in polygon of the layer causes to not possible (red color), individual check (yellow), generally possible (green).

These information`s and the respective GIS-dataset build up the GIS-based conflict layer.

If for one location more than one conflict layer appears, the most problematic layer indicates the resulting colour.

With GIS-data preparation the defined rules can be added to a polygon layer for several areas of red, yellow or green colours. Two main possibilities of processing were tested and evaluated during a Saxon geothermal research study (LfULG, 2017):

- Intersection and colorization of all ***polygon layer***,
- Combination and colorization of ***grid data***.

Both possibilities have positive and negative aspects. The testing showed that the polygon layer based variant is linked with a high extra effort, if there are grid-based date to be included into a polygon-based traffic light map. Additional changes of the information layers are linked with higher maintenance expenditure.

As result of the evaluated possibilities to process traffic-light maps a grid-based workflow and visualization is recommended.

3.3.3. Map of specific land use risks and conflicts

According to table 1 different layer of possible land use conflicts has to be derived. Already available layers like protection areas as polygon shapes can be directly included into the category layer. This information can be added as thematic layers to the traffic light map for expert users like at IOG Bavaria (Nr 54).

Additionally the derived geological 3D data can be shown directly or as single interpreted virtual boreholes.

The possible resulting damages of every single conflict layer cannot be presented. These layers are still information data for expert users like geothermal consulter, drilling companies or environmental authorities.

3.4. Modelling workflows for land use risk and conflict information

In evaluation of the screened projects a possible schematic workflow for GeoPLASMA-CE of all derived conflict information layers and traffic light maps is shown at figure 4. First the information of specific land use risks and conflicts has to be defined and derived from the available data of each pilot area (3D-model, parameter list developed in WPT3). In most cases the data has to be developed or reclassified via GIS-tools like attribute selection, intersection, buffering and merging. If the created layers cover only parts of the pilot area, this has to be noticed e.g. via a layer of availability.

Each conflict information data generates input for the traffic light map. This input (suggestion for red, yellow, green color) influences the presentation of the traffic light maps for the possible geothermal system. The traffic light maps will be presented once for open loop systems and once for closed loop systems.

Additionally the interpreted conflict information layers are presented as own layers like tectonics, karst, and protection areas etc. (figure 4, 8).

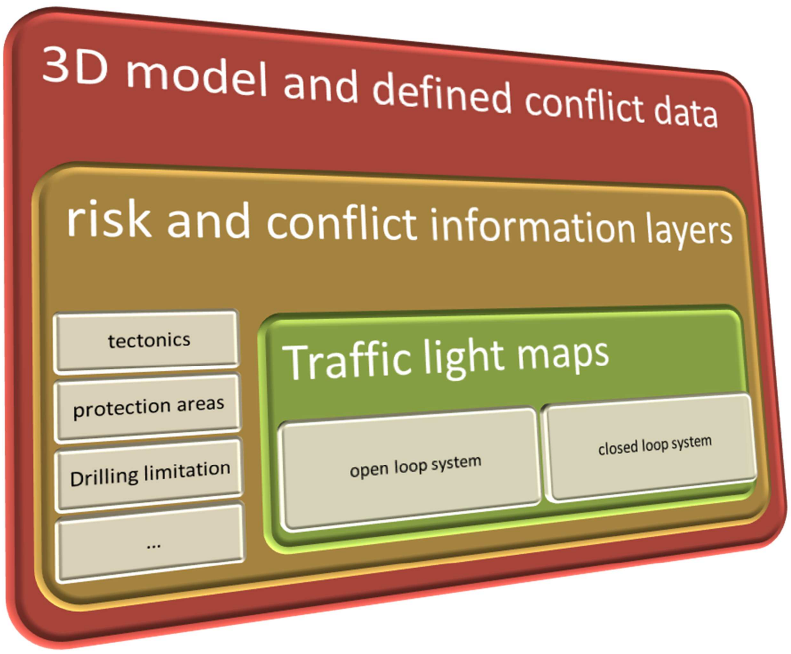

Figure 4: schematic workflow for conflict mapping.

3.5. Interpreted information and visualization

The interpreted information is visualised via a web portal, to be available for the interested public and experts. The literature and methodology research revealed that not many conflict maps are already available in Europe. The assessed traffic light maps or conflict maps of Germany are very different in interpretation and presentation of risks. At Geothermieportal NRW a traffic light map is just available for closed loop systems (figure 5). NIBIS of Niedersachsen also shows the conflict areas just for closed loop systems. The traffic light map is differentiated into red, blue and green colours, in which the blue category is divided up into 10 sub-categories related to specific conflict themes (figure 6).

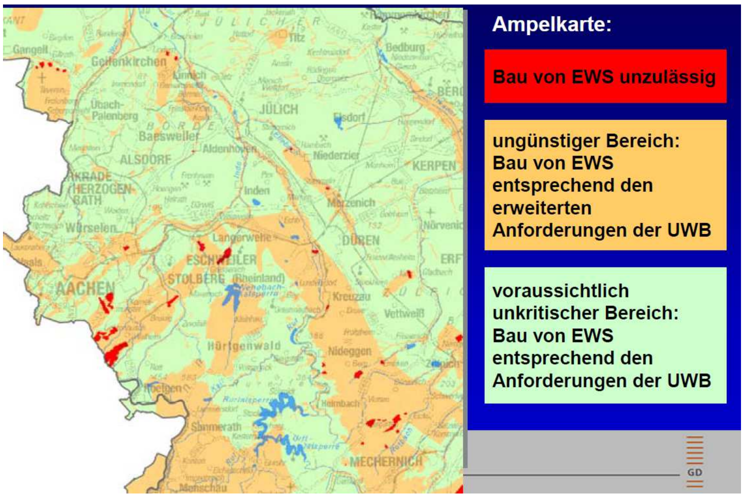

Figure 5: Traffic light map NRW.

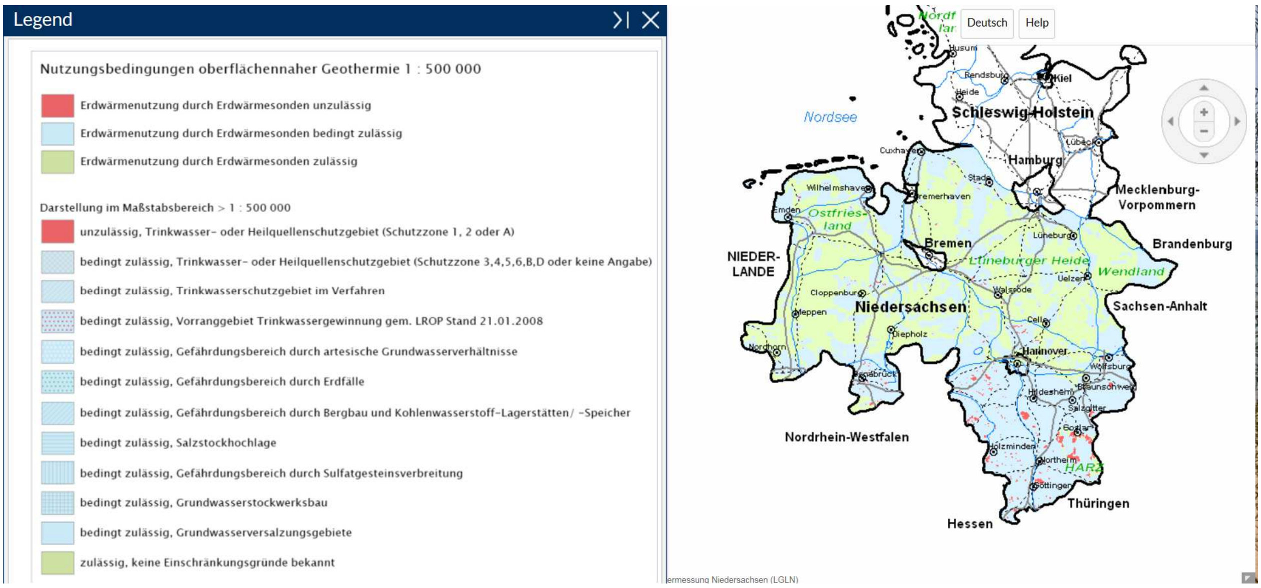

Figure 6: Traffic light map and conflict mapping NIBIS (Niedersachsen).

IOG (Bavaria) shows recommendations via a map of suitable geothermal systems and distinguishes between open loop and closed loop geothermal systems as traffic light map. Additionally IOG presents some specific conflict layers like borehole limitations.

The LfULG study shows that a grid-based visualization of conflict data is the best way to process a traffic light map. That means that every input layer has to be rasterized. In this way automatically all properties of the polygons are exported to colour channels of the grid layers. After that a summarized grid of all grid layers is generated which builds the base of the traffic light map. At this summarized grid every input (grid) layer represents one channel. The visualization will be done of the predefined rules from the summarized grid into the traffic light colours (figure 7).

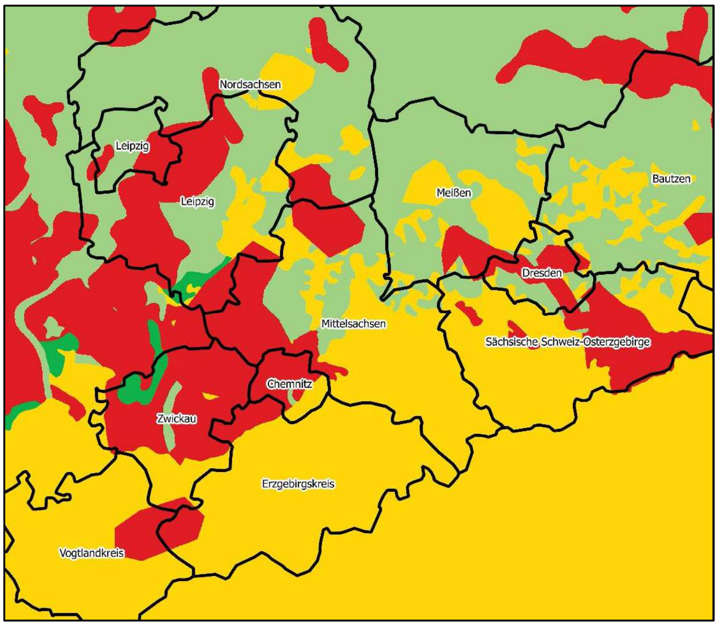

Figure 7: Visualization possibility of traffic light map based on grid data (example: no real existing map, testing) (LfULG study, 2017).

The traffic light maps should be presented for open loop systems as well as for closed loop systems. Additional to this overview of a suitable and recommended geothermal system the several specific land-use risk and conflict information have to be visualized as several selectable layers too. Figure 8 shows the generally structure of a land use risk and conflict information.

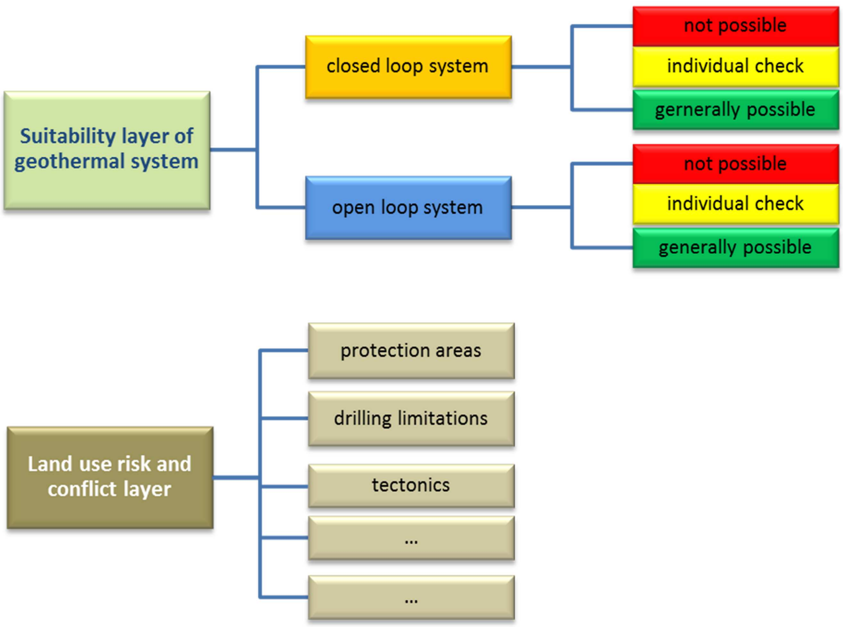

Figure 8: Schematic structure of visualization of land use risk and conflict information.

Additionally, the visualisation of all maps need some explanation tools how to handle the different maps and some legal aspects, e.g. that geothermal potential maps are related to a certain scale and do not replace any accurate design and calculation of a geothermal plant.

4. Summary and Conclusions

All aspects from both geothermal systems (closed loop systems, open loop systems) should be included into the conflict mapping for GeoPLASMA-CE. The visualisation can be achieved for example via a “traffic light map” which additionally shows the suitability of geothermal systems in order to provide a general information about possible geothermal use. This can be enhanced for experts via specific information layers of conflicts and land use risks.

The approach to develop these maps and information layers for GeoPLASMA-CE should be harmonized. The individual interpretation, if a geothermal system is possible/recommended or not depends on geological, hydrogeological and legal restrictions. Therefore, thishas to be defined separately for each pilot area/country.

Figure 9 shows a possible visualisation scheme of all relevant maps and information layers for shallow geothermal energy usages. A thematic listing of easily understandable maps like the suitability map of geothermal systems, including the traffic light maps and geothermal heat extraction maps can be followed by specified thematic layers like thermal conductivity maps, temperature maps as well as conflict layer, 3D-geology, tectonic maps, groundwater information etc.

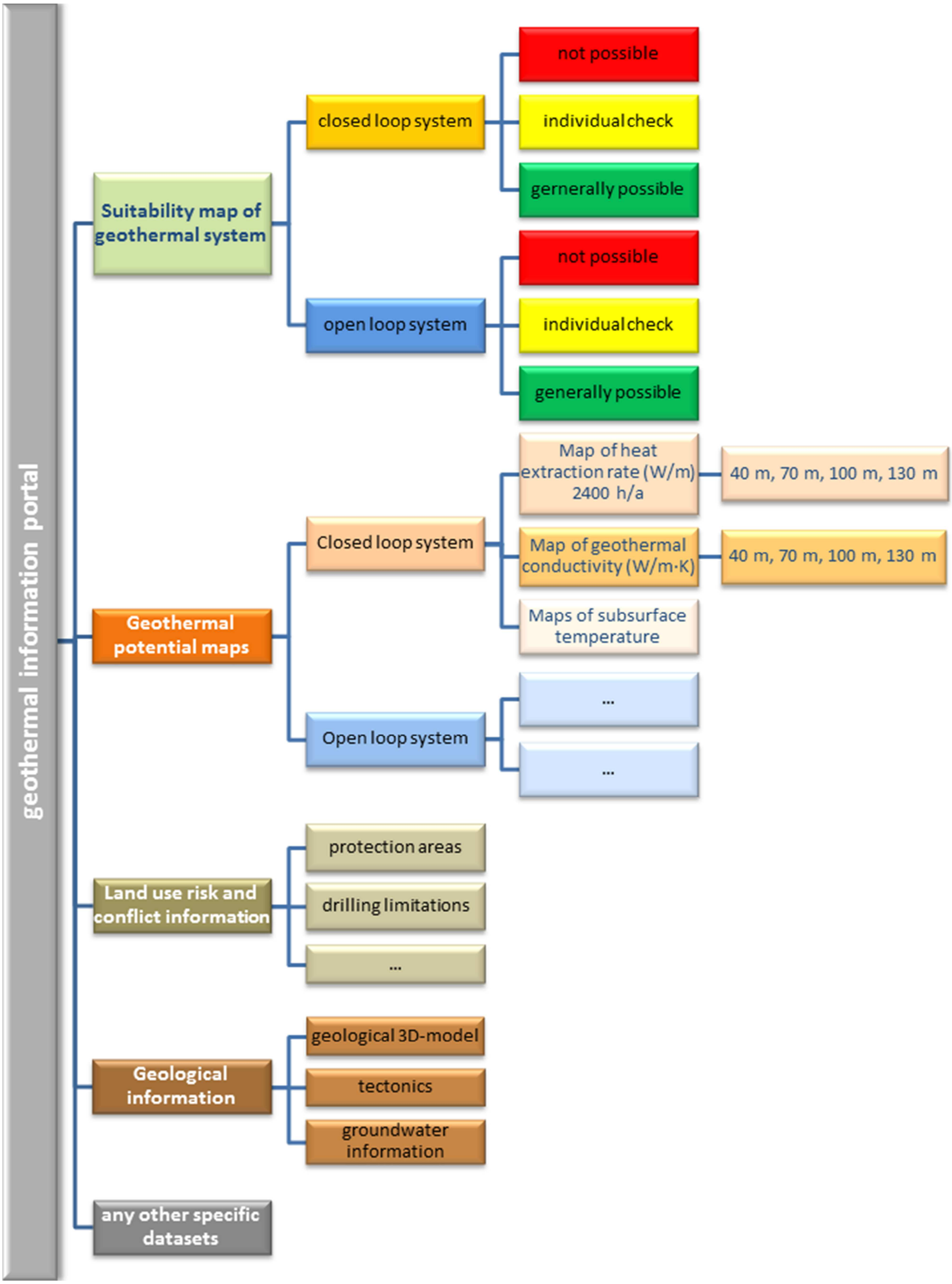

Figure 9: Possible visualization scheme of a geothermal information portal.

5. References

A research of literature gives an overview of already existing methods of geological based 3D-modelling, geothermal potential mapping in general and land-use-conflict mapping related to geothermal energy. The results of this research are compiled into a developed "knowledge repository".

63 national and international publications of projects related to the main topics of GeoPLASMA-CE are stored for further research in the database "knowledge repository". These projects and publications were assessed and are partly linked to workpackages of GeoPLASMA-CE. The main focus of the research was the methodical approach to geological 3D-modelling, geothermal mapping for open and closed loop systems and land-use conflict mapping concerning geothermal potential mapping in non-urban and urban areas. Additionally there were found other interlinks to technical workpackages 1, 3 and 4 and some possible experiences for workpackage communication.

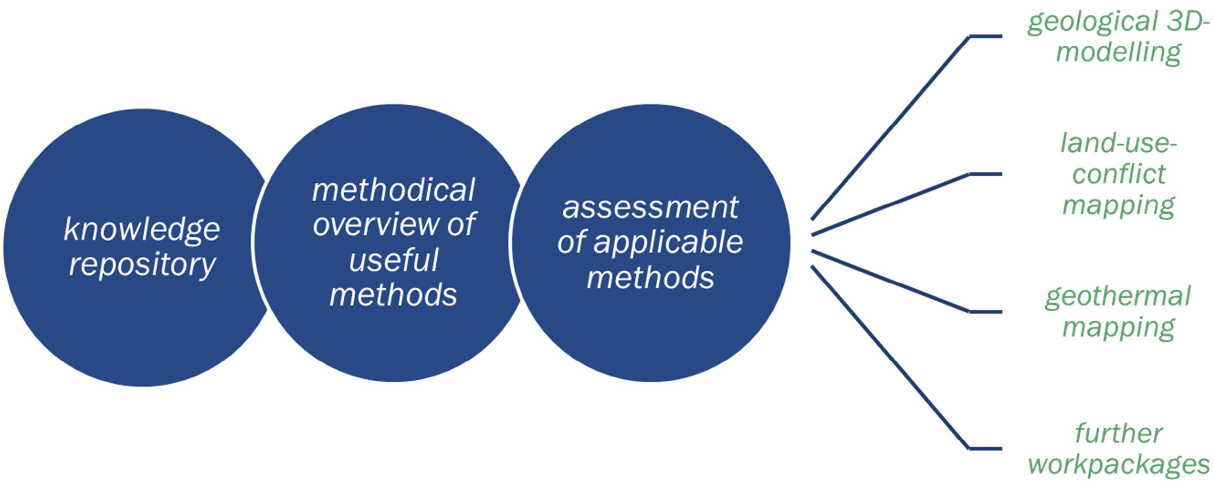

Figure 10: methodical research

The list of the knowledge repository with the methodical assessment sheets and links to other workpackages is summarized in the following table 5.

All assessment sheets are added in Annex 1 for further information.

Table 5: knowledge repository methodical research

ID	literature type	Year/ last access date	Author	Title	Publisher, journal issue, vol., pp.	usefull for WP	linked to WP	Keyword1	Keyword2	Keyword3	web link (if available)
1	published	2014	Arola, T., Eskola, L., Hellen, J., Korkka-Niemi, K.	Mapping the low enthalpy geothermal potential of shallow Quaternary aquifers in Finland	Springer, Geothermal Energy, vol. 2, 9	TWP2		potential mapping	open-loop system		
2	published	2014	LfULG, PGI	Handbuch zur Erstellung von geothermischen Karten auf der Basis eines grenzübergreifenden 3D-Untergrundmodells; Podręcznik opracowywania map geotermicznych na bazie transgranicznego trójwymiarowego (3D) modelu podłoża	Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie;Państwowy Instytut Geologiczny - Państwowy Instytut Badawczy, Oddział Dolnośląski (PIG-PIB OD)	TWP2	TWP4	3D-modelling	potential mapping	use in regional areas	http://www.transgeotherm.eu/publikationen.html
3	published	2015	LfULG	TransGeoTherm - Erdwärmepotenzial in der Neiße-Region	Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie, Schriftenreihe	TWP2	TWP4	3D-modelling	(hydro)geology of pilot area	use in regional areas	http://www.transgeotherm.eu/publikationen.html
4	unpublished	2015	Peters, A.	Oberflächennahes geothermisches Potential in Thüringen	Thüringer Landesanstalt für Umwelt und Geologie	TWP2	TWP3	potential mapping	use in regional areas	closed-loop system	
5	published	2017	Dahlqvist, P., Epting, J., Huggenberger ,P., García Gil, A	Shallow geothermal energy in urban areas	In Groundwater, Geothermal Modelling and Monitoring at City-Scale (Bonsor et al.). TU1206 COST Sub-Urban WG2 Report (p. 22-38).	TWP2	TWP3	use in urban areas	open-loop system	closed-loop system	https://static1.squarespace.com/static/542bc753e4b0a87901dd6258/t/58aebaeaebbd1a4c4b9ab469/1487846145333/TU1206-WG2.4-005+Groundwater%2C+Geothermal+modelling+and+monitoring+at+city+scale.pdf
6	published	2013	Zosseder, G., Chavez-Kus, L., Somogyi, G., Kotyla, P., Kerl, M., Wagner, B., Kainzmaier, B.	GEPO - Geothermisches Potenzial der Münchener Schotterebene Abschätzung des geothermischen Potenzials im oberflächennahen Untergrund des quartären Grundwasserleiters des Großraum Münchens. GEPO - Geothermal potential of the Munich Gravel Plain Assessment of the geothermal potential in the shallow subsurface of the Quaternary aquifer in the Greater Munich.	19. Tagung für Ingenieurgeologie mit Forum für junge Ingenieurgeologen München 2013	TWP2		field measurements	groundwater	use in urban areas	
7	published	2014	Götzl, G., Fuchsluger, M., Rodler, A., Lipiarski, P., Pfleiderer, S.	Projekt WC-31 Erdwärmepotenzialerhebung Stadtgebiet Wien, Modul 1	Abteilung MA20 - Energieplanung des Magistrats der Stadt Wien	TWP2	TWP3	potential mapping	open-loop system	closed-loop system	https://www.wien.gv.at/stadtentwicklung/energieplanung/stadtplan/erdwaerme/erlaeuterungen.html
8	published	2014	LfULG, PGI	Informationsbroschüre zur Nutzung oberflächennaher Geothermie, Broszura informacyjna na temat stosowania płytkiej geotermii	Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie; Państwowy Instytut Geologiczny - Państwowy Instytut Badawczy, Oddział Dolnośląski (PIG-PIB OD)	TWP4		closed-loop system	quality standards	policy strategies	http://www.transgeotherm.eu/publikationen.html
9	published	2016	Malík, P., Švasta, J., Gregor, M., Bačová, N., Bahnová, N., Pažická, A.	Slovak Basic Hydrogeological Maps at a Scale of 1:50,000 - Compilation Methodology, Standardised GIS Processing and Contemporary Country Coverage	State Geological Institute of Dionýz Štúr Bratislava 2016, Slovak Republic, Slovak Geological Magazine, vol.16, no.1, ISSN 1335-096X	TWP2	TWP1	groundwater	(hydro)geology of pilot area	use in regional areas	

ID	literature type	Year/ last access date	Author	Title	Publisher, journal issue, vol., pp.	usefull for WP	linked to WP	Keyword1	Keyword2	Keyword3	web link (if available)
10	published	2016	Bodiš, D., Rapant, S., Kordík, J., Slaninka, I.	Groundwater Quality Presentation in Basic Hydrogeochemical Maps at a Scale of 1:50,000 by Digital Data Treatment Applied in the Slovak Republic	State Geological Institute of Dionýz Štúr Bratislava 2016, Slovak Republic, Slovak Geological Magazine, vol.16, no.1, ISSN 1335-096X	TWP2		groundwater	quality standards	use in regional areas	
11	published	2016	Fričovský, B., Černák, R., Marcin, D., Benková, K.	A First Contribution on Thermodynamic Analysis and Classification of Geothermal Resources of The Western Carpathians (an engineering approach)	State Geological Institute of Dionýz Štúr Bratislava 2016, Slovak Republic, Slovak Geological Magazine, vol.16, no.1, ISSN 1335-096X	TWP2		heat storage	groundwater	use in regional areas	
12	published	2014	Ditlefsen, C., Sorensen, I., Slott, M., Hansen, M.	Estimation thermal conductivity from lithological descriptions - a new web-based tool for planning of ground-source heating and cooling	Geologcial Survey of Denmark and Greenland Bulletin, vol.31, 55-58	TWP2	TWP1	closed-loop system	thermal conductivity		http://geuskort.geus.dk/termiskejordarter/
13	published	2004	Goodman, R., Jones, G. Ll., Kelly, J., Slowey, E., O'Neill, N.	Geothermal Resource Map of Ireland	Sustainable Energy Authority of Ireland	TWP2	TWP1	closed-loop system	open-loop system	potential mapping	http://maps.seai.ie/geothermal/
14	published	2010	Goodman, R., Jones, G. Ll., Kelly, J.	Methodology in Assessment and Presentation of Low Enthalpy Geothermal Resouces in Ireland	World Geothermal Congress 2010	TWP2	TWP1	field measurements	3D-modelling		
15	published	22.11.2016		ThermoMap		TWP2	TWP1	closed-loop system	potential mapping	(hydro)geology of pilot area	http://www.thermomap-project.eu/
16	published	2012	Abesser, C.	Technical Guide - A screening tool for open-loop ground source heat pump schemes (England and Wales)	BGS and EA	TWP2		open-loop system	potential mapping	groundwater	http://mapapps2.bgs.ac.uk/gshpnational/home.html
17	published	2012	Rajver, D., Pestotnik, S., Prestor, J., Lapanje, A., Rman, N., Janža, M.	Possibility of utilisation geothermal heat pumps in Slovenia (Geothermal resources in Slovenia)	Geological Survey of Slovenia, Bulletin Mineral resources in Slovenia 2012, (165-175)	TWP2		potential mapping	use in regional areas		http://www.geo-zs.si/PDF/PeriodicnePublikacije/Bilten_2012.pdf
18	published	2016	Borović, S., Urumović, K., Terzić, J.	Determination of subsurface thermal properties for heat pump utilization in croatia	Third Congress of Geologists of Republic of Macedonia.	TWP2	TWP3	field measurements	closed-loop system		http://geothermalmapping.fsb.hr
19	published	2015	Holeček J., Burda J., Bílý P., Novák P., Semíková H	Metodika stanovení podmínek ochrany při využívání tepelné energie zemské kůry	GEOTERMAL,TAČR project No.: TB030MZP024	TWP2	TWP4	land-use conflicts			
20	unpublished	2013		Tepelná čerpadla pro využití energetického potenciálu podzemních vod a horninového prostředí z vrtů (Heat pumps and exploitation of the energy potential of underground water and rock environment from wells)		TWP2	TWP4				
21	unpublished	2009	P. Hanžl, S. Čech, J. Čurda, Š. Doležalová, K. Dušek,P. Gürtlerová, Z. Krejčí, P. Kycl, O. Man,D. Mašek, P. Mixa, O. Moravcová, J. Pertoldová,Z. Petáková, A. Petrová, P. Rambousek,Z. Skácelová, P. Štěpánek, J. Večeřa, V. Žáček,	Basic guidelines for the preparation of a geological map of the Czech Republic 1: 25000		TWP2		3D-modelling			

ID	literature type	Year/ last access date	Author	Title	Publisher, journal issue, vol., pp.	usefull for WP	linked to WP	Keyword1	Keyword2	Keyword3	web link (if available)
22	published	2016	Götzl, G., Pfleiderer, S., Fuchsluger, M., Bottig, M., Lipiarski, P.	Projekt SC-27, Pilotstudie „Informationsinitiative Oberflächennahe Geothermie für das Land Salzburg (IIOG-S)	Geologische Bundesanstalt	TWP2		closed-loop system	open-loop system	potential mapping	
23	published	2013	van der Meulen	3D geolopgy in a 2D country: perspectives for geological surveying in the Netherlands	Netherlands Journal of Geosiences, 92-4, page 217-241, 2013	TWP2		3D-modelling			
24	published	2015	LfU	GeoMol - Assessing subsurface potentials of the Alpine Foreland Basins for sustainable planning and use of natural resources. Project Report		TWP2		potential mapping			http://www.geomol.eu
25	published		Agemar (2014, 2016) Gocad-Anwendertreffen	GeoTIS		TWP2	TWP1	3D-modelling	potential mapping		https://www.geotis.de/geotisapp/geotis.php
26	published		LBRG	ISONG: Informationssystem für oberflächennahe Geothermie Baden Württemberg		TWP2	TWP1	3D-modelling	potential mapping	land-use-conflict mapping	http://isong.lgrb-bw.de/
27	published	2007	Joris Ondreka, Maike Inga Rüsgen, Ingrid Stober, Kurt Czurda	ISONG: GIS-supported mapping of shallow geothermal potential of representative areas in south-western Germany—Possibilities and limitations	Renewable Energy 32 (2007) 2186-2200	TWP2	TWP1	potential mapping	closed-loop system	3D-modelling	
28	published	2014	LfULG	Geothermieatlas Sachsen: Allgemeine Erläuterungen zum Kartenwerk der geothermischen Entzugsleistungen im Maßstab 1:50 000 GTK 50	Sächsisches Landesamt für Umwelt, Landwirtschaft und GeologiePillnitzer Platz 3, 01326 Dresden	TWP2	TWP3	potential mapping	closed-loop system	use in regional areas	
29	unpublished			TUNB		TWP2					
30	published	2015	D. Bertermann, H. Klug, L. Morper-Busch	A pan-European planning basis for estimating the very shallow geothermal energy potentials	Renewable Energy 75 (2015) 335-347	TWP2		potential mapping			
31	published	2016	Casasso, Sethi	G.POT A quantitative method for the assessment and mapping of the shallow geothermal potential		TWP2		potential mapping			
32	published	2015	Galgaro et al.	Empirical modeling of maps of geo-exchange potential for shallow geothermal energy at regional scale		TWP2		potential mapping			
33	published		Phillipe Dumas et al.	ReGeoCities Final Report		TWP4		use in urban areas	policy strategies	quality standards	
34	published	2011	Gemelli, Mancini, Longhi	GIS-based energy-economic model of low temperature geothermal resources A case study in the Italian Marche region	Renewable Energy 36 (2011) 2474-2483	TWP2		policy strategies			
35	published	2002	Hamada et al.	Study on underground thermal characteristics by using digital national land information, and its application for energy utilization	Applied Energy 72 (2002) 659-675	TWP2		potential mapping			
36	published	2016	Hein et al.	Potential of shallow geothermal energy extractable by Borehole Heat Exchanger coupled Ground Source Heat Pump systems	Energy Convension and Management 127 (2016) 80-89	TWP2		potential mapping	closed-loop system		
37	published	2011	Nam, Ooka	Development of potential map for ground and groundwater heat pump systems and the application to Tokyo		TWP2		potential mapping	use in urban areas		

ID	literature type	Year/ last access date	Author	Title	Publisher, journal issue, vol., pp.	usefull for WP	linked to WP	Keyword1	Keyword2	Keyword3	web link (if available)
38	published			Adriatic IPA project LEGEND: Low enthalpy geothermal energy demonstration		TWP4		quality standards	policy strategies		http://www.adriaticipacbc.org/login.asp
39	published			Cheap-GSHPs: Cheap and efficient application of reliable ground source heat exchangers and pumps		TWP2	TWP4	quality standards	policy strategies		http://cheap-gshp.eu/
40	website			COST-Action GABI: Geothermal energy Applications in Buildings and Infrastructure		TWP4		quality standards	potential mapping		https://www.foundationgeotherm.org/
41	website			EGIP: European Geothermal Information Platform		WPC		policy strategies			http://egip.igg.cnr.it/
42	published			FROnT: Fair Renewable Heating and Cooling Options and Trade		TWP4	WPC	policy strategies	quality standards		http://www.front-rhc.eu/
43	website			GEOTeCH: Geothermal Technology for €conomic Cooling and Heating		WPC	TWP3	field measureme nts	quality standards		http://www.geotech-project.eu/
44	website			Geothermal ERA-NET		TWP1	WPC	use in regional areas	policy strategies		http://www.geothermaleranet.is/
45	published			GEOTRAINET: Geo-Education for a sustainable geothermal heating and cooling market		TWP4	WPC	quality standards			http://geotrainet.eu/
46	website			Green Epile: Development and implementation of a new generation of energy piles		WPC					http://cordis.europa.eu/project/rcn/204589_e n.html
47	published			IMAGE: Integrated Methods for Advanced Geothermal Exploration		TWP2	TWP3	field measureme nts	use in regional areas		http://www.image-fp7.eu/Pages/default.aspx
48	website			ITER: Improving Thermal Efficiency of horizontal ground heat exchangers		WPC		monitoring	field measuremen ts		http://iter-geo.eu/
49	website			ITHERLAB: In-situ thermal rock properties lab		TWP3		field measureme nts			http://cordis.europa.eu/project/rcn/201131_e n.html
50	website			TERRE:Training Engineers and Researchers to Rethink geotechnical Engineering for a low carbon future		WPC		quality standards			http://www.terre-etn.com/
51	website			TESSe2b:Thermal Energy Storage Systems for Energy Efficient Buildings. An integrated solution for residential building energy storage by solar and geothermal resources		TWP4		heat storage	quality standards		http://www.tesse2b.eu/tesse2b/newsTesse2bP roject
52	website			TRANSENERGY, legal aspect of transboundary aquifer management		TWP2	TWP4	3D-modelling			http://transenergy-eu.geologie.ac.at/
53	website	2016		GRETA		TWP2	TWP4	quality standards	use in regional areas	policy strategies	http://www.alpine-space.eu/projects/greta/en/home http://www.alpine-space.eu/projects/greta/en/project-results/reports/deliverables
54	website		LfU	IOG Bayern	LfU	TWP2	TWP1	open-loop system	closed-loop system	land-use-conflict mapping	http://www.lfu.bayern.de/geologie/geothermi e_iog/
55	website		LBEG	NIBIS, Niedersachsen	LBEG	TWP2	TWP1	potential mapping	land-use-conflict mapping	3D-modelling	http://nibis.lbeg.de/cardomap3/

ID	literature type	Year/ last access date	Author	Title	Publisher, journal issue, vol., pp.	usefull for WP	linked to WP	Keyword1	Keyword2	Keyword3	web link (if available)
56	website		lgb-rlp	Rheinland Pfalz	lgb-rlp	TWP2	TWP1	potential mapping	3D-modelling	land-use-conflict mapping	http://www.lgb-rlp.de/karten-und-produkte/online-karten/online-karten-geothermie.html
57	website		LLUR	Schleswig Holstein	LLUR	TWP2	TWP1	potential mapping			
58	published	Jun 16	Tina Zivec, Elea iC d.o.o., Slovenia	Markovec_USING 3D GEOLOGICAL MODELLING IN CIVIL INDUSTRY	3rd Europeanmeeting on 3D geologicalmodelling	TWP2		3D-modelling			
59	published	2014	S. J. Mathers, R. L. Terrington, C. N. Waters and A. G. Leslie	GB3D – a framework for the bedrock geology of Great Britain	Geoscience Data Journal 1: 30-42 (2014), RMetS	TWP2	TWP1	3D-modelling			
60	published	2011	Ad-hoc-AG Geologie, PK Geothermie	Fachbericht zu bisher bekannten Auswirkungen geothermischer Vorhaben in den Bundesländern		TWP2	TWP4	quality standards	land-use-conflict mapping		http://www.infogeo.de/home/geothermie/dokumente/index_html?sfb=8&sdok_typ=-1&skurzbeschreibung=
61	website		Geologischer Dienst NRW	Portal Geothermie Nordrhein-Westfalen	Geologischer Dienst NRW	TWP2	TWP1	closed-loop system	land-use-conflict mapping		http://www.geothermie.nrw.de
62	published	2016	GSI	Ground Source Heating/Cooling System Suitability Maps - Open Loop Systems	GSI	TWP2	TWP2	open-loop system	potential mapping		
63	published	2016	GSI	Ground Source Heating/Cooling System Suitability Maps - Closed Loop Systems	GSI	TWP2	TWP2	closed-loop system	potential mapping		
64	published	2017	Jannis Epting, Alejandro García-Gil, Peter Huggenberger, Enric Vázquez-Suñe, Matthias H. Mueller	Development of concepts for the management of thermal resources in urban areas – Assessment of transferability from the Basel (Switzerland) and Zaragoza (Spain) case studies	Journal of Hydrology 548 (2017) 697-715	TWP2	TWP3	use in urban areas	open-loop system	potential mapping	http://www.sciencedirect.com/science/article/pii/S0022169417301993
65	published	2016	Götzl, G., Fuchsluger, M., Steiner, C.	Projekt WC-33 Potenzialkarte für die integrative Planung thermischer Grundwassernutzungen in Aspern Nord	GBA	TWP2	TWP3	use in urban areas	open-loop system	potential mapping	
66	published	2006	Götzl, G., Ostermann, V., Kalasek, R., Heimrath, R., Steckler, P., Zottl, A., Novak, A., Haindlmaier, G., Hackl, R., Shadlau, S., Reitner, H.	GEO-Pot Seichtes Geothermie Potenzial Österreichs. Überregionale, interdisziplinäre Potenzialstudie zur Erhebung und Darstellung des oberflächennahen geothermischen Anwendungspotenzials auf Grundlage eines regelmäßigen Bearbeitungsratsers	OEWAV 5-6/2010, Springer	TWP2	TWP3	closed-loop system	potential mapping		

Annex 1: methodical assessment sheets

Assessment sheet – SC 27, Shallow geothermal potential, State of Salzburg

Please use this sheet for summarizing realized methods and approaches on both national as well as international level. Use one sheet per project / initiative and make sure to upload reports screened for this assessment on the joint knowledge repository, even in case the report is only available in national language!

Please insert information in the blue colored fields.

ID knowledge repository As indicated in register at Own Cloud	22	Reference Please use format: Author, Year, Title, Journal, Publisher	Götzl, G., Pfleiderer, S., Fuchsluger, M., Bottig, M., Lipiarski, P., 2016, Projekt SC-27, Pilotstudie „Informationsinitiative Oberflächennahe Geothermie für das Land Salzburg (IIOG-S), GBA

Territorial coverage of study / initiative National – please indicate country; international – please indicate participating countries	State of Salzburg

Thematic coverage of study / initiative Please tick topics		3D modelling methods with regard to the mapping of utilization potentials and risks
	x	Mapping of potential: open loop systems
	x	Mapping of potential: closed loop systems
		Mapping of land-use conflicts and risks, environmental impact assessment

Shallow geothermal utilization methods covered by project / initiative Please specify systems (e.g. borehole heat exchanger, groundwater well, horizontal collector)	Closed loop systems: - Borehole heat exchangers Open loop systems: - Groundwater heat pumps

Executive summary / synopsis of the report Maximum 1000 characters
This project is a pilot study for the development of a digital information system for shallow geothermal applications in the state of Salzburg, Austria. The objectives of the project were to create geothermal potential maps for ground water heat pumps and borehole heat exchangers in the areas of permanent settlement and to support the government of Salzburg to compile concepts for the practical application of this study's products.

The initial approach included potential maps, scale 1:200 000, which were intended to be made available via web viewer and as printable maps. This idea was discarded for different reasons and instead the query for a location should create reports, providing the information about shallow geothermal potential.

Description of applied approach (methods and workflow) for mapping

Closed loop systems

- The bottom line of each sediment basin was defined, using geological maps, elevation model and borehole profiles.
- Based on the geological maps a simplified geological map without sediments of the basin was derived, to estimate the heat conductivity below the basin.
- Based on these two layers a map for heat conductivity was generated, using heat conductivity values from literature studies (VDI4640, data compilation of GBA)

Open loop systems

The potential for thermal use of shallow groundwater was divided into two sub-potentials (hydraulic and thermic sub-potential).

- Thermic sub-potential:
  The thermic sub-potential is determined from the available temperature difference between ground water and injection temperature of the geothermal application. This also equals the thermic groundwater potential. The guideline ÖWAV 207 limits the temperature changes of the groundwater resulting from its thermal use. Considering these limitations the thermic groundwater potential (=temperature difference between extraction (T_e) and injection well (T_i)) can be written as:

  $$\Delta T = \left| T_e - T_i \right|_{5°C}^{20°C} \right| \leq 5°C$$

- Hydraulic sub-potential:
  The hydraulic sub-potential is derived from the maximum discharge available. The discharge available depends on the hydraulic conductivity and the thickness of the groundwater, according to the chosen approach. The hydraulic slope, depth to the water table and well geometry are excluded. The discharge available (Q) is calculated using Thiem's approach:

  $$Q = \pi \cdot kf \frac{5 \cdot H_{MGW}^2}{9 \cdot lnR} \text{ [m}^3\text{/s]}$$

  Kf = hydraulic conductivity [m/s]
  H_{NGW} = hydraulic active thickness of groundwater body at low water level
  R = hydraulic range. $R = 3000 \cdot \left(\frac{H_{MGW}}{3}\right) \cdot \sqrt{kf}$

- Technical application potential:
  The total thermal potential represents the technical application potential and is derived from the combination of the two sub-potentials:
  P [W] = $\Delta T \cdot \langle cp \cdot \rho \rangle \cdot Q$
  ΔT = Difference of temperature between extraction and injection well
  $cp \cdot \rho$ = Volumetric heat capacity of ground water [J/m³/K]

Q = Discharge of well doublet [m³/s]

The licensed discharges were used as auxiliary quantity to determine the technical application potential for locations where the hydraulic sub-potential could not be calculated due to missing data.

Description of input data used for mapping
Please make a general sketch, no detailed data lists (e.g. hydrogeological maps scale 1:50.000)

Closed loop systems
- Geological maps of Salzburg
- Borehole profiles
- Elevation model
- Soil temperatures
- Thermal Response Tests
- Literature compilation of heat conductivities

Open loop systems
- Licensed discharges for peak loads of existing applications
- Literature compilation of hydraulic conductivities
- Hydrogeological maps

Description of output parameters and data-formats of results
e.g. printed maps including the scale, GIS based maps, interactive web-systems

The outputs of this project have not been implemented in a web based information system until now. Information about the following parameters, which are considered as crucial for the determination of the shallow geothermal potential, has been compiled on scale 1: 200 000.

Closed loop systems
- Heat conductivity map (depth: 0 – 100 m)
- Soil temperature map

Using this information and the geometry, material, and operation of method of the borehole heat exchanger, it is possible to determine the best design of the closed loop system.

Open loop systems
- Outline of hydrogeologically suitable areas
- Hydraulic sub-potential: Maximum discharge for well doublets
- Thermic sub-potential: Maximum temperature difference for well doublets
- Technical application potential: Maximum power for well doublets

Description of the suitability of the chosen approach for GeoPLASMA-CE
Please write a short review about the pros and cons of the chosen approach! Is that approach suitable for GeoPLASMA-CE?

PROs
The developed approach of this project is considered to be very good for the creation of shallow geothermal potential maps.

Heat conductivity values of different rock types are considered.

CONs
Although the depth to 100 m is sufficient for standard BHEs, another map of the heat conductivity for an additional depth interval (eg. – 200m) would be good extension.

The hydraulic conductivity is the most sensitive parameter for the developed approach for open loop systems. Therefore this approach is only suitable for pilot areas, where the hydraulic conductivity is known well.

GeotIS- geothermal information system of Germany

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Please insert information in the blue colored fields.

ID knowledge repository As indicated in register at Own Cloud	25	Reference Please use format: Author, Year, Title, Journal, Publisher	https://www.geotis.de/geotisapp/geotis.php *AGEMAR, T., ALTEN, J., GANZ, B., KUDER, J., KÜHNE, K., SCHUMACHER, S. & SCHULZ, R. (2014): The Geothermal Information System for Germany - GeotIS – ZDGG Band 165 Heft 2, 129–144"* *AGEMAR, T., WEBER, J. & SCHULZ, R. (2014): Deep Geothermal Energy Production in Germany – Energies 2014 Band 7 Heft 7, 4397–4416*

Territorial coverage of study / initiative National – please indicate country; international – please indicate participating countries	Germany, main focus on the North German Basin, Upper rhine graben, south German Molasses Basin

Thematic coverage of study / initiative Please tick topics	x	3D modelling methods with regard to the mapping of utilization potentials and risks
	x	Mapping of potential: open loop systems
		Mapping of potential: closed loop systems
	x	Mapping of land-use conflicts and risks, environmental impact assessment

Shallow geothermal utilization methods covered by project / initiative	3D geological/structural model Deep aquifers Temperature model

Executive summary / synopsis of the report Maximum 1000 characters
3D model of major faults and horizons (TSURFS) Extraction of 2D and unit-wise SGrids Temperature interpolation from measuements in drill holes Heat production capacity or mean power production

3D modelling software
Gocad-Skua
Input data
GeoTectonicAtlas, maps, seismic, contour maps
Description of applied approach (methods and workflow)
3Dmodelling of main horizons and faults →Triangulated surfaces Extraction of 2D grids or of SGrids unitwise-unconnected Generation of a voxet for the temperature simulation
Output data
2D grid: 100 m Voxel: 2000 m horizontal, 100 m vertical
Advantages
2D grid: simple generation of cross-sections, small storage SGrid: representation of complex fault patterns Surfaces and volumina can be parameterized
Disadvantages
2D grid: overturned and thrusted structures get lost during data conversion from TSURF Holes along normal faults Fault geometry is not part of the 2D horizon grids Conversion from TSURF to 2D-grid is necessary No parameterization of the geological bodies is possible→ average for each vertical “line”
Description of the suitability of the chosen approach for GeoPLASMA-CE
Web platform may give ideas

Parameter and potential model Input data
Voxel Temperature measurements from drillings
Software
Gocad-Skua?
Output data
Temperatures
Approach/Workflow
Temperature of the subsurface universal kriging of temperature data
Output data
Advantages
Disadvantages
Suitability for Geoplasma

Suggestion for the visualization of temperature maps (depth-levels, temperature-levels, horizons)

Potential maps Input data
Software
Output data
Isopache maps for the bases of stratigraphic units Thickness maps Temperature maps on varius depth level (1000, 1500, 2000, 3000, 4000 m) Depth of 60, 100, 150 °C isotherm Annual heat extraction capacity MWh/a Permanent heat extraction kW
Approach/Workflow
Output data
Advantages
Very flexible and open for all kinds of software
Disadvantages
Results are not comparable
Suitability for Geoplasma
Suggestion for the visualization of temperature maps (depth-levels, temperature-levels, horizons)

Risk and landuse conflicts Input data
Faults, Salt strucutres
Software
Output data
Map with faults and salt structures not interpreted

Suitability for Geoplasma

ISONG – information system surface near geothermal energy

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Please insert information in the blue colored fields.

ID knowledge repository As indicated in register at Own Cloud	26	Reference Please use format: Author, Year, Title, Journal, Publisher	http://isong.lgrb-bw.de/

Territorial coverage of study / initiative National – please indicate country; international – please indicate participating countries	Baden-Württemberg 400 m depth

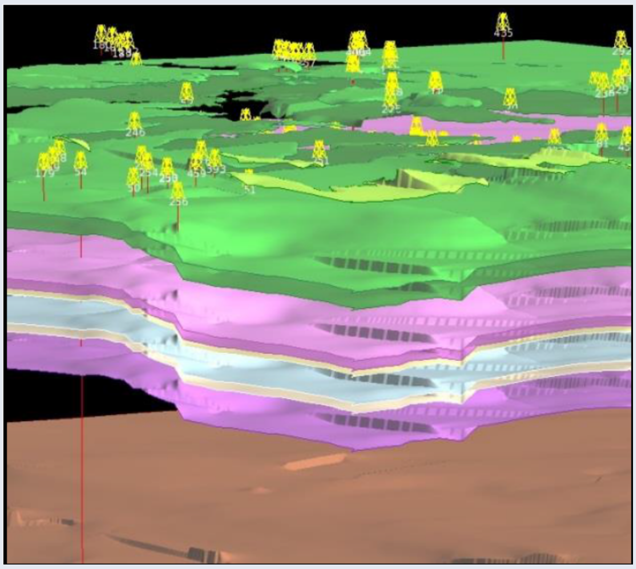
Thematic coverage of study / initiative Please tick topics	x	3D modelling methods with regard to the mapping of utilization potentials and risks
	x	Mapping of potential: open loop systems
	x	Mapping of potential: closed loop systems
	x	Mapping of land-use conflicts and risks, environmental impact assessment

Shallow geothermal utilization methods covered by project / initiative	

Executive summary / synopsis of the report Maximum 1000 characters

3D modelling software
Gocad
Input data
Drillings, geological maps, isopach maps
Description of applied approach (methods and workflow)
3D model of major faults and horizons (TSURFS)

Modelling from DGM Downward
Thickness distributions
Solid from Thickness
Extract TSurf FROM sOLID



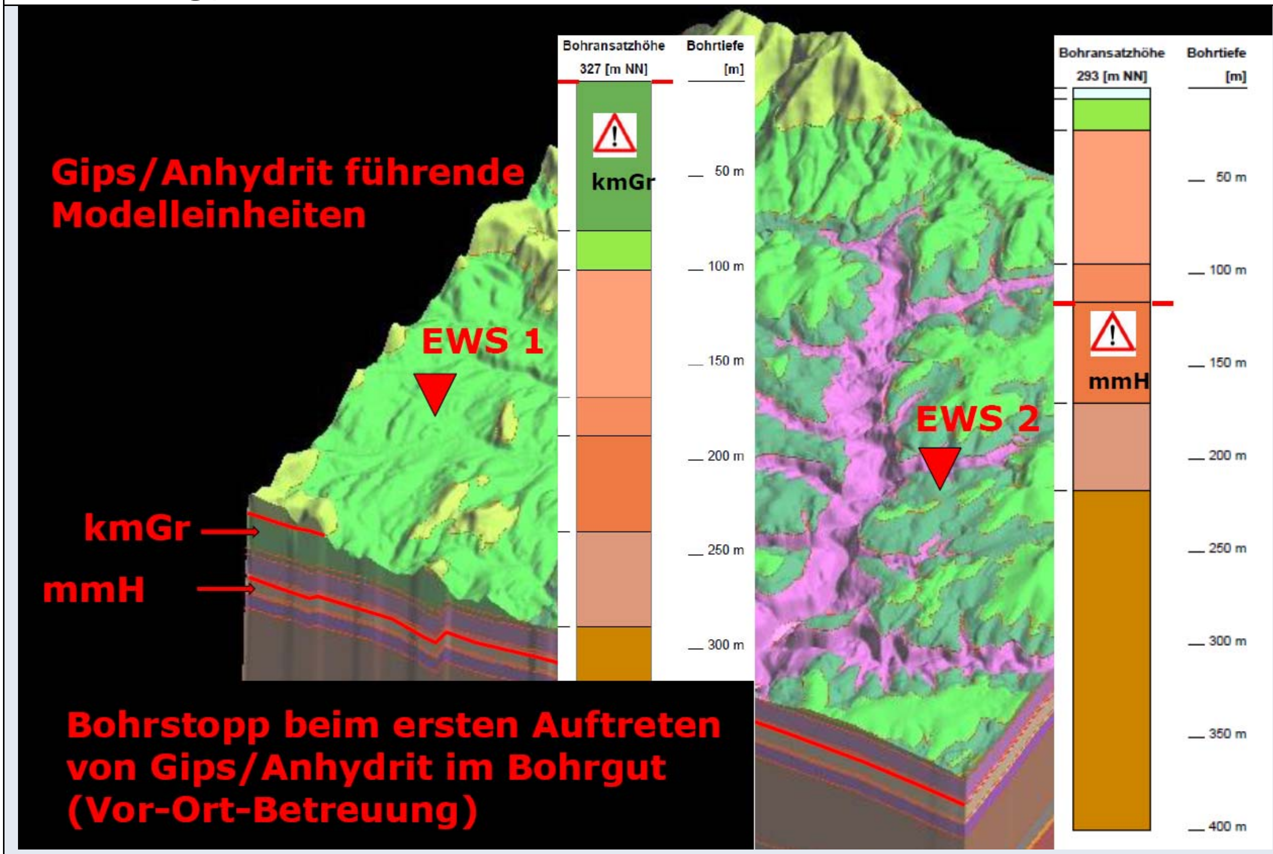
Output data
3D geological/structural model 1:50 000 TSurf horizon base
Advantages
No horizon crossings are possible
Disadvantages
Topography can be seen in the lowest horizons although the morphology of the horizon is not constrained by data
Description of the suitability of the chosen approach for GeoPLASMA-CE

Parameter and potential model Input data
Regionalized geothermal gradients
Software
?
Approach/Workflow
Analytical a-proiri model ? Calibration based on residuals
Output data
heat extraction capacity

Advantages
Disadvantages
Suitability for Geoplasma

potential maps Input data
Software
Output data
Specific heat extraction capacity for houses heating systems working 1800 h/a (only heating) or 2400 h/a (heating and hot water production)
Approach/Workflow
Output data
Advantages
Disadvantages
Suitability for Geoplasma

Conflict maps maps Input data
Maps for protection zones: drinking, mineral and curative water Information from 3D model: limitation of drilling depth (swellable rocks) Artesian springs and aquifers
Software
Output data
Prognostic drilling profile Indicating the geological units, artesic groundwater, swellable rocks, limitation of drilling depth
Approach/Workflow

Output data Virtual drilling profile

Advantages
Disadvantages
Suitability for Geoplasma
Prognostic drilling path for one location with risks