This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 792355.

Deliverable D4.8

GEO4CIVHIC DSS for geothermal retrofit user manual

WP4

Grant Agreement number	792355
Project acronym	GEO4CIVHIC
Project full title	Most Easy, Efficient and Low Cost **Geo**thermal Systems **for** Retrofitting **Civ**il and **Hi**storic**a**l Buildings
Due date of deliverable	30/09/2021 (M42)
Lead beneficiary	7 – TECNALIA
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Dissemination Level

PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	
CI	Classified, as referred to in Commission Decision 2001/844/EC	

Document History

Version	Date	Authors	Description
1	01/09/21	Sarah Noyé, Amaia Castelruiz (TECNALIA)	Creation of the document and table of content
2	23/09/21	Amaia Castelruiz, Sarah Noyé (TECNALIA)	Draft for reviewers
3	28/09/21	Francesca Bampa, Iuliia Kozlova (UNESCO)	Revised version
4	28/09/21	RGS	Revised version
5	29/09/21	Amaia Castelruiz, Sarah Noyé (TECNALIA)	Final version for Coordinator
6	30/09/21	Adriana Bernardi (CNR-ISAC)	Final check
7	30/09/21		Upload in ECAS

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Contents

Publishable summary

The D4.8 "GEO4CIVHIC DSS for geothermal retrofit user manual" is a public document delivered in the context of WP4, Task 4.3: "DSS implementation for civil and historical buildings geothermal retrofit".

The current document represents the user manual of the web-based Decision Support System developed in the project. The instructions for managing the user account, creating and configuring projects and easily following the different steps of the calculation process will be presented. The flexibility of the tool, which adapts to different levels of user expertise will also be shown. Finally, the document will give indications for the users to interpret the results provided by the website.

Abbreviations

GEO4CIVHIC	Most Easy, Efficient and Low Cost **Geo**thermal Systems **for** Retrofitting **Civ**il and **Hi**stori**c**al Buildings
DSS	**D**ecision **S**upport **S**ystem
GSHE	**G**round **S**ource **H**eat **E**xchanger
GSHP	**G**round **S**ource **H**eat **P**ump
HE	**H**eat **E**xchanger
HP	**H**eat **P**ump
KPI	**K**ey **P**erformance **I**ndicator

Introduction

The target of the GEO4CIVHIC project is to accelerate the deployment of shallow geothermal systems for heating and cooling in retrofitting existing and historical buildings. One of the actions taken by the project to reach this target, is the development of a decision support tool, with a holistic approach, to identify the most appropriate solutions for a given installation. The tool will assist the user in the identification of the preferred solutions for each particular case, and will perform a pre-engineering cost and impact analysis for each one of them.

This Decision Support Tool, or DSS, is available to the public through a free-access website.

https://geo4civhic.onyxsoft.co/

The tool will also be accessible from the GEO4CIVHIC project website[1].

The use of this tool will help raising awareness towards geothermal technologies, increasing their credibility and finally supporting the implementation of geothermal installations.

The current document is the user manual of this GEO4CIVHIC DSS. **Section 1** presents a general description of the website, establishing the objective of the tool and giving an overall view of the process and the followed steps.

Next, **Section 2** contains the instructions for users to take advantage of the different services implemented. The different steps of the process are detailed, with a short overview of each step and the different phases in which it can be split. In each case, the information that needs to be entered (if any) and the different options available to the user are presented.

[1] https://geo4civhic.eu/

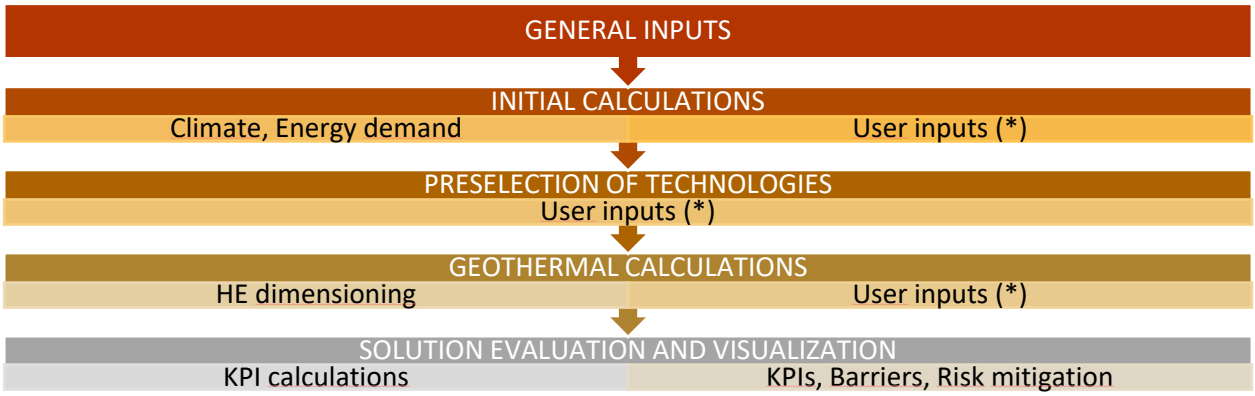
1 General description of the website

The DSS aims to provide with a rapid pre-project assessment. The objective of the tool is to perform a pre-engineering cost and impact analysis to convince building owners to install GSHP systems. The final purpose of the DSS is to facilitate pre-design discussion around the installation of a GSHP in a retrofit project in an urban environment.

This will serve, on one side, for decision makers to understand the benefit of investing in GSHP and, on the other hand, for GSHP experts to contract projects with this technology. The DSS will also have an educative value for other stakeholders of energy renovation.

The user of the tool is not expected to have expert knowledge in geothermal energy. After the general input introduction, in the following steps of the process, the tool is capable of giving estimations of the information requested to the user (the so-called default values, calculated from the specific project inputs). This makes the tool usable for non-expert users, although it also adds a level of uncertainty to the results. For that reason, if users have high level of expertise or have more accurate information for some of the requested parameters, they are allowed to enter them in the tool, ignoring those default values and thus obtaining more reliable results.

Main features and functionality of the website will be explained in the sections below. For more clarity, the process has been split into different steps:



Step 1: Basic Inputs. The first step of the calculation will be the introduction of general inputs by the users. Simple inputs will be requested, such as the localization, the type of building or the planned level of retrofit.

Step 2: Additional inputs. In this step, climate information and energy demand values, necessary for the upcoming calculations, are estimated. In order to minimize the assumptions made in the calculations as much as possible, with the aim to provide reliable results, the users will also have the opportunity to introduce more accurate values themselves.

Step 3: Solution preselection. The system calculates the most suitable drilling technology and heat pump model for each project. These technologies will be combined with the different types of heat exchanger to form each possible solution. The users can choose up to three solutions for the system to analyze.

Step 4: Geothermal calculations. After fixing all the inputs, the geothermal calculations will be performed for the selected solutions. The calculations will be based on the ASHRAE method[2] and will obtain the size of the heat exchanger installation. Again, users are allowed to modify the calculated values, in case they want to include some custom solutions in the analysis.

Step 5: Solution evaluation. Once all the solutions have been calculated and dimensioned, they are characterized according to technical, environmental and economic KPIs. These characterizations will be presented to the users to assist them in the comparison of the analyzed solutions and in the final decision making.

All the information related to this process is arranged in projects. Each project contains the following information:

- Facility description (basic information such as the location or the type of building)
- Additional inputs calculated or introduced by the user
- A set of feasible geothermal solutions, each of which will be a combination of:
    - Heat Exchanger (type, dimension)
    - Heat Pump
    - Additional energy sources (if necessary)
- Solution technical, economic and environmental characterization

Each registered user can have different projects, thus being able to use the system for different facilities or to change some parameters and view their effects on the results.

All the tasks related to the management of users and their projects are gathered under the **Step 0: User login and project set-up**.

The different steps of the process will be detailed in the next Section.

[2] S.P. Kavanaugh, K. Rafferty, Ground-source Heat Pumps - Design of Geothermal System for Commercial and Institutional Buildings ASHRAE Applications Handbook, Atlanta, GA, US, 1997.

2 Use of the website

2.1 STEP 0: USER LOGIN AND PROJECT SET-UP

The initial scenario involves the registering of users and the project set-up. It allows end-users to register and log-in to the system. Once logged-in, the user can manage projects (create a new project or either edit or delete an existing one.

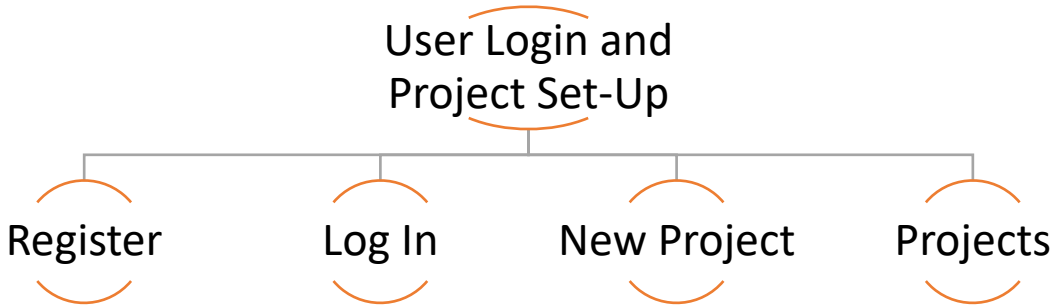


Figure 1. User Log in and Set up steps

Phase 1: Register

Users must be registered on the system in order to access and use the tool.

Information requested for the registration:

- Email Address
- Password

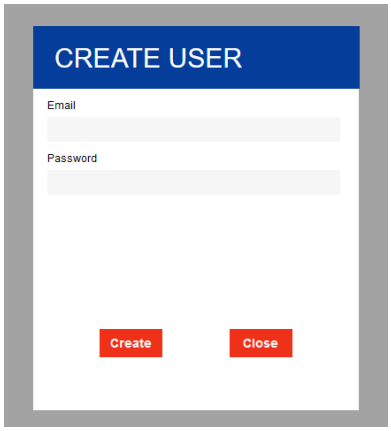


Figure 2. GEO4CIVHIC DSS Website - Register form

Phase 2: Log in

Once users have a valid account, they can log-in.

Information required for log-in:

- Email Address
- Password

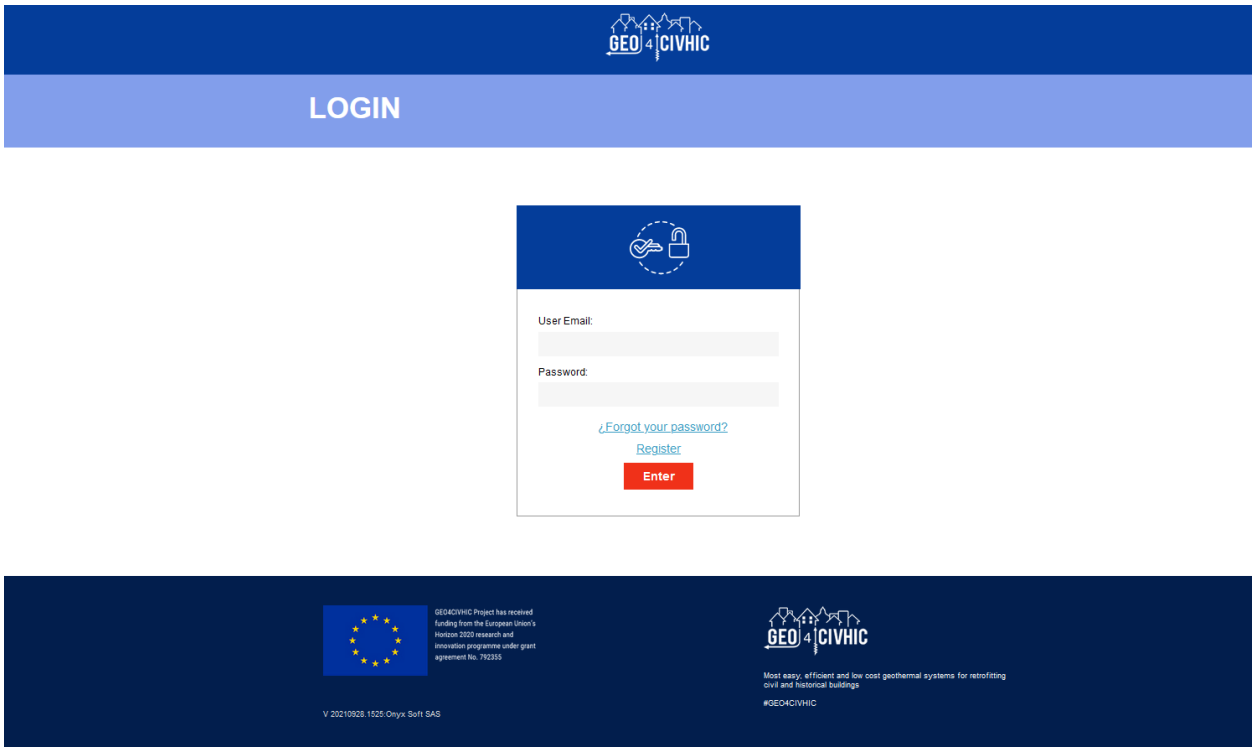


Figure 3. GEO4CIVHIC DSS Website - Log-in page

If users forget their password, they can click on the “Forgot your password?” link. They will receive an email with instructions to recover their password.

Phase 3: New Project

After the first login into the website, an empty project list is presented to the user.

Figure 4. GEO4CIVHIC DSS Website – Empty project list

This page gives an option to create a new project through the “New” button.

The new project creation process requires the following information:

- Project Name: Name that will be used to identify the project.
- Project Description: Additional information describing the project.

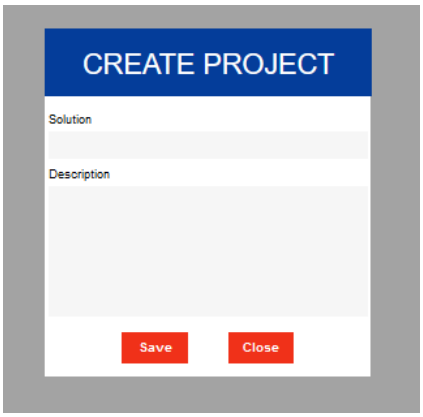


Figure 5. GEO4CIVHIC DSS Website – Project setup

Phase 4: Projects

After creating the project, the users are sent back to the project list. From this list, the users can manage projects, creating a new one, deleting existing projects or entering a specific project.

Figure 6. GEO4CIVHIC DSS Website - Project list

2.2 STEP 1: BASIC INPUT INTRODUCTION

In this step end-users can provide some basic information that describes the retrofit project they want to evaluate. The application allows the user to define the building type, the retrofit scenario, information regarding the current systems installed, the location and sizing of the facilities and information of the ground characterization.

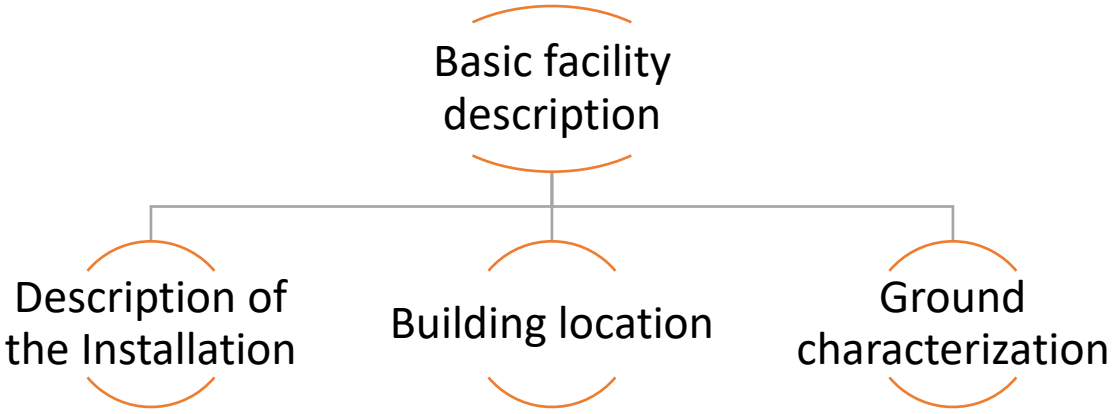


Figure 7. GEO4CIVHIC DSS Website – Basic facility description steps

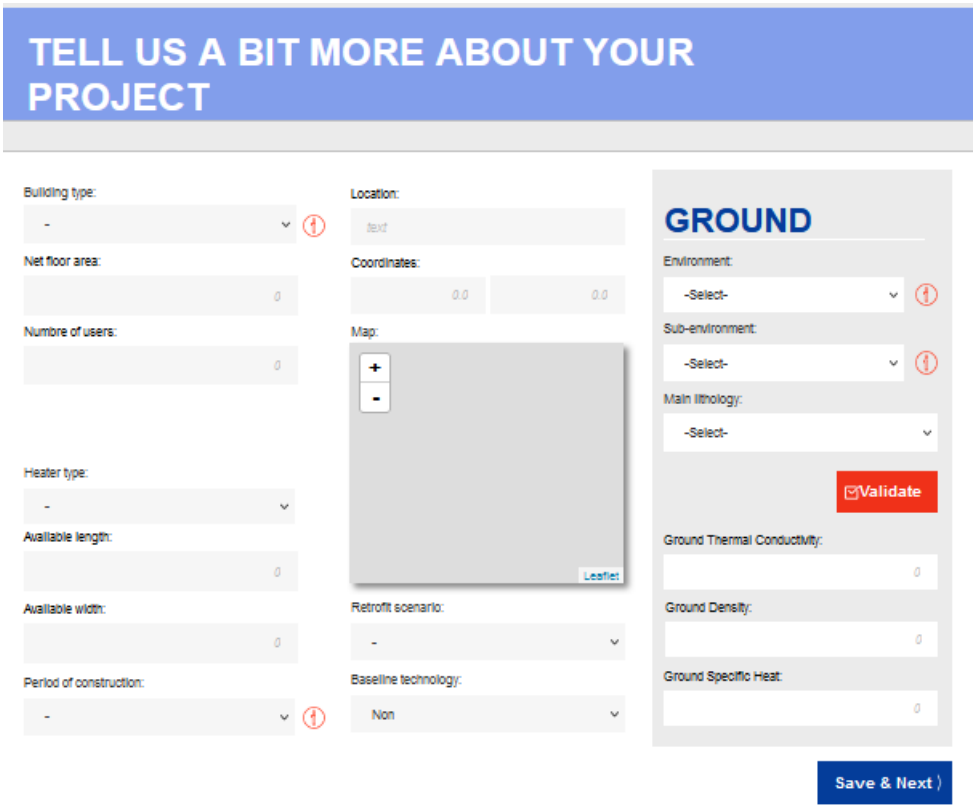


Figure 8. GEO4CIVHIC DSS Website – Project detail description page

Phase 1: Installation details

The user shall enter the following details about the installation:

- Select the building type:
  - Office building
  - Apartment block
  - Terrace house
- Enter the net floor area (m^2)
- Enter the number of users in the building
- Select the heater type (after the retrofit activities, indicating the new type of heater if it's going to be modified):
  - Radiator
  - Radiant panel
  - Fan coil
- Enter available space for the installation (length and width (m))
- Select the period of construction of the building:
  - Historic (pre-1960)
  - Civil (post-1960)
- Select the retrofit scenario for the system to evaluate. Four scenarios have been set-up, depending on the elements included in the simulated retrofit project:
  - The boiler is substituted by a ground source heat pump
  - The boiler is substituted by a ground source heat pump and new terminal units are installed.
  - The boiler is substituted by a ground source heat pump and the insulation of the building is improved
  - The boiler is substituted by a ground source heat pump, new terminal units are installed, and the insulation of the building is installed.

Phase 2: Building location

The user should enter the location of the building. The location will be seen on the map, and the coordinates (latitude and longitude will be filled). The user can also enter directly the coordinates if they are known.

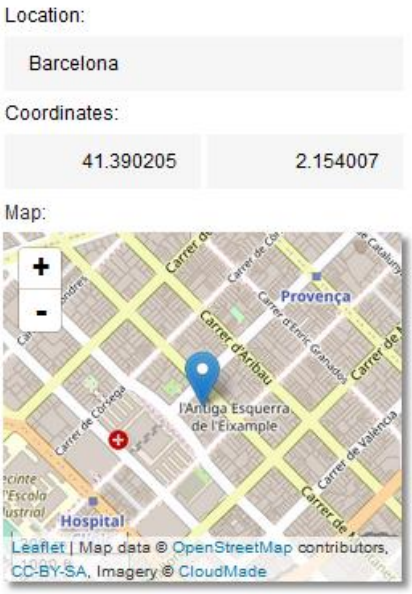


Figure 9. GEO4CIVHIC DSS Website - Location definition form

Phase 3: Ground characterization

The objective of this phase is to obtain the ground characterization values of the installation location: ground thermal conductivity, ground density and ground specific heat.

Case 3.a) The user knows the values of the ground characterization

If the user knows this information, it can be entered in the form directly. The user can then click on the “SAVE AND NEXT” button and proceed.

Case 3.b) The user does not know the values of the ground characterization

In case the user does know these values, they can be estimated by the tool. For that purpose, first, the user shall choose the environment and sub-environment corresponding to the location of the facilities.

Next, to facilitate the choice of these values, the different possible options are described. [3]

Environment 1. Alluvial plain

An alluvial plain is a largely flat landform created by the deposition of sediment over a long period of time by one or more rivers coming from highland regions, from which alluvial deposits forms. It is a level or gently sloping surface formed of sediments laid down by streams, generally during flooding and bordered by flat-lying areas consisting of floodplains, lakes, and peatlands.

[3] **All image copyright by Eloisa Di Sipio**

Sub-environment 1.1 High plain

Part of an alluvial plain near the hillslopes, formed by coarse-grained detrital sediments, prevalently gravels, sometime irregularly cemented in conglomerate horizons and intercalated with sand and less frequently with thin silty-clayey layers.

Sub-environment 1.2 Low plain

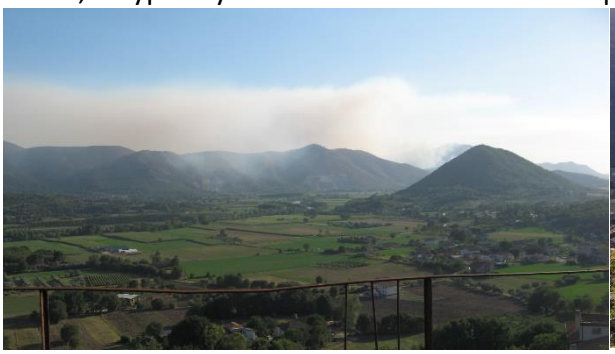
Part of an alluvial plain, located between high plain and the coastline, mainly characterized by sand and clay deposits, rarely intercalated with gravel layers. These sediments could be partly of fluvial origin and partly of marine, lagoon and marshy origin, depending on its geological history.

Environment 2. Mountain-Hill area

These areas can be defined as a sequences of linked slope units running from drainage divide to valley floor. Valleys slopes may be considered as rock environment, thin soils may cover them, or they may comprise a mix of rock and unconsolidated slope deposits.

Sub-environment 2.1 Valley floors

A low area of land between hills or mountains, which deposits are usually a mix of gravels and/or sands, is typically related to river stream transport.



Sub-environment 2.2 Rock slope (high local relief)

Slopes generally formed by rocks (hard or soft rock, depends on the environment) are known as rock slope.


Environment 3. Coastal area

The coast, also known as the coastline or seashore, is defined as the area where land meets the sea or ocean, or as a line that forms the boundary between the land and the ocean or a lake.

Sub-environment 3.1 Rocky coast

It refers to coasts that have rocky outcrops, often, but not necessarily, in the form of cliffs and shore platforms.

Cliffs are steep or vertical slopes that rise precipitously from the sea or from a basal platform. About 80% of the world’s oceanic coasts are edged with cliffs. Rock coasts are one of the most common elements of the world's littoral zone.


Shore platform stands for horizontal or gently sloping surfaces backed by a cliff, eroded in bedrock at the shore. The erosional origin of these surfaces is evident because they cut across and expose geological structures.

Sub-environment 3.2 Coastal environments

Beaches are the most significant accumulations of sediments along coasts. They form in the zone where wave processes affect coastal sediments. In composition, they consist of a range of organic and inorganic particles, mostly sands and/or pebbles.

Estuaries and lakes: an estuary is an area where a freshwater river or stream meets the ocean, while a lake is a large area of water surrounded by land and not connected to the sea except by rivers or streams. Both of them are characterized by silt-clay sediments prevalence and also sand deposits.

Coastal dunes are heaps of windblown sediment deposited at the edge of large lakes and seas. With few exceptions, they are made from sediment blown off a beach to accumulate in areas sheltered from the action of waves and currents.

After choosing the environment and sub-environment, the user should click on the “Validate” button for the default ground characterization (ground thermal conductivity, density and specific heat) values to be filled.

Then, the user can click on the “Save and Next” button and proceed.

2.3 STEP 2: ADDITIONAL INPUTS

The second step in the project definition process is the retrieval of additional inputs related to the climate and the energy demand of the building. In each case, two options are given to the users: the introduction of the information by themselves or the obtaining of default values that correspond to an estimation of the values calculated from the inputs introduced in the previous step.

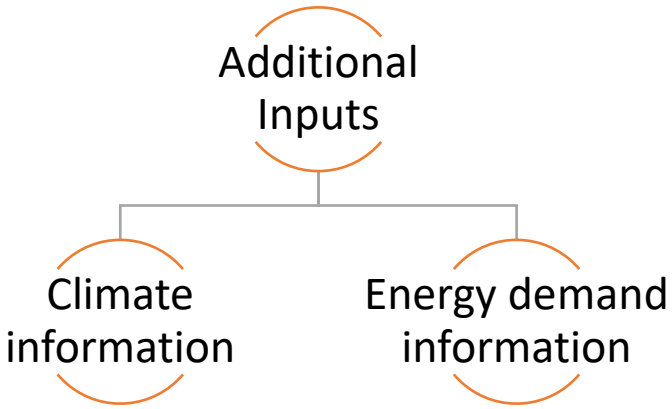


Figure 10. Additional input definition step

Phase 1: Climate

The information that needs to be fulfilled regarding the climate is:

- The ground temperature (ºC)
- The monthly average temperature (ºC)
- The monthly average solar radiation (W / m2)

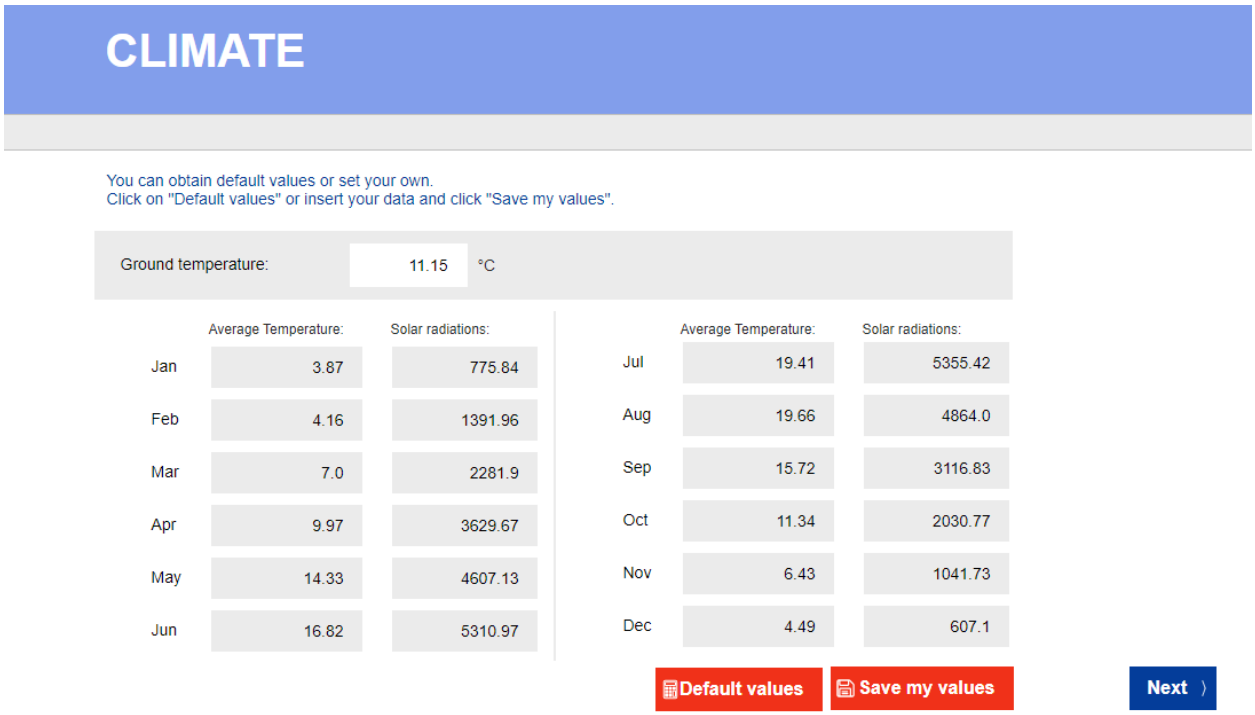


Figure 11. GEO4CIVHIC DSS Website - Climate information

If users have the information, they can fill-in the boxes and click on the “Save my values” button. Otherwise, they should click on the “Default values” button, then they should press the “Next” button, to access the next phase of the process.

Phase 2. Energy demand

The necessary information regarding the energy demand is:

- Peak consumption (for Heating, Cooling and Domestic Hot Water) (kWh)
- Monthly consumptions (for Heating, Cooling and Domestic Hot Water) (kWh)

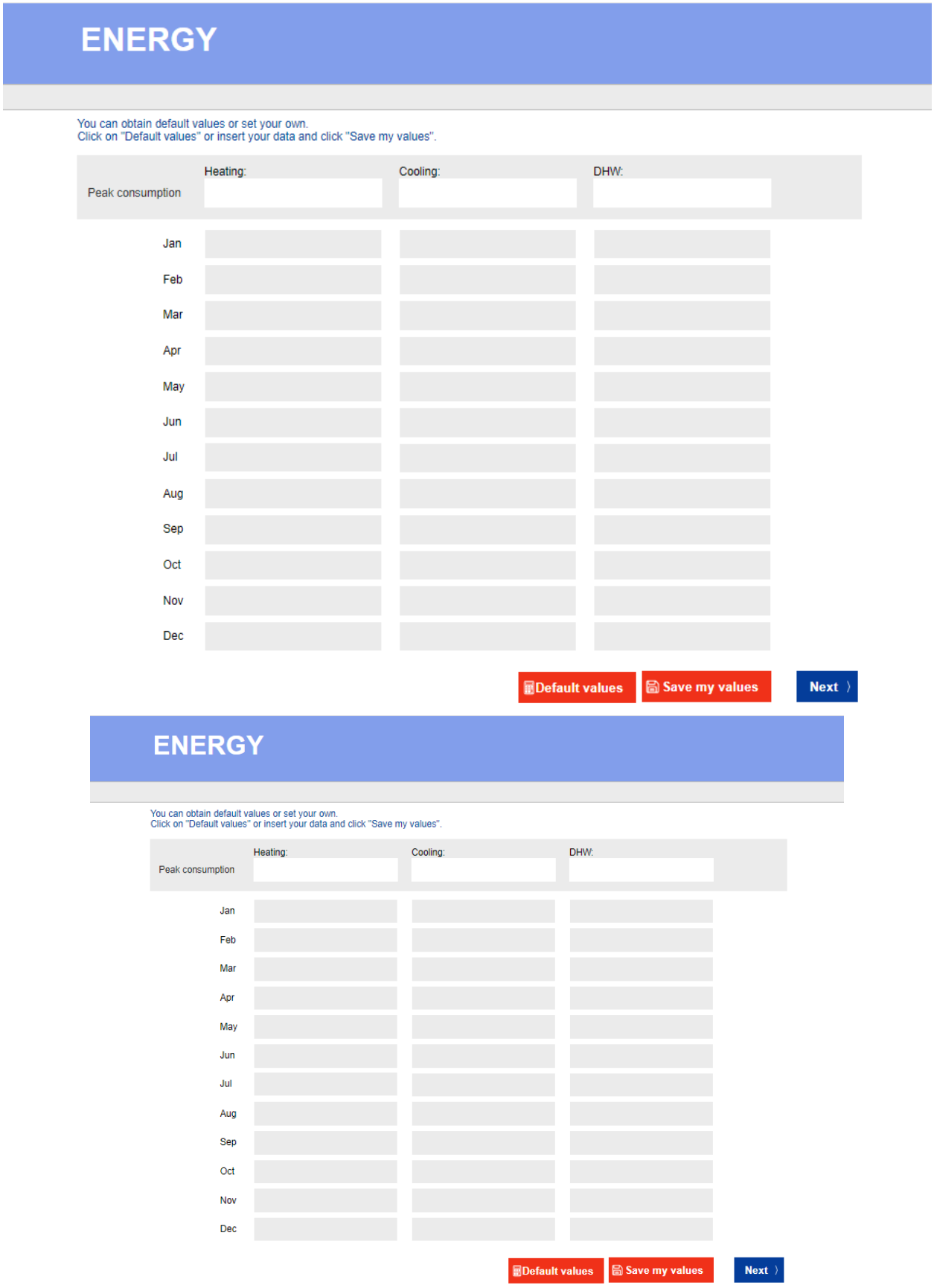


Figure 12. GEO4CIVHIC DSS Website - Energy demand information

Again, if users have the information, they can fill-in the boxes and click on the “Save my values” button. Otherwise, they should click on the “Default values” button. For both cases, then they should press the “Next” button, to access the next step of the process.

2.4 STEP 3. SOLUTION PRESELECTION

After the introduction of all the necessary information, the system can already calculate a pre-selection of technologies. The system will choose the optimal Heat Pump and drilling technologies for the project. These technologies will be combined with different types of Heat Exchangers in order to form the Solutions presented to the user.

The user can choose up to three solutions for their evaluation and comparison. Besides, the users is allowed to enter custom values for the technologies of the different solutions for their evaluation.

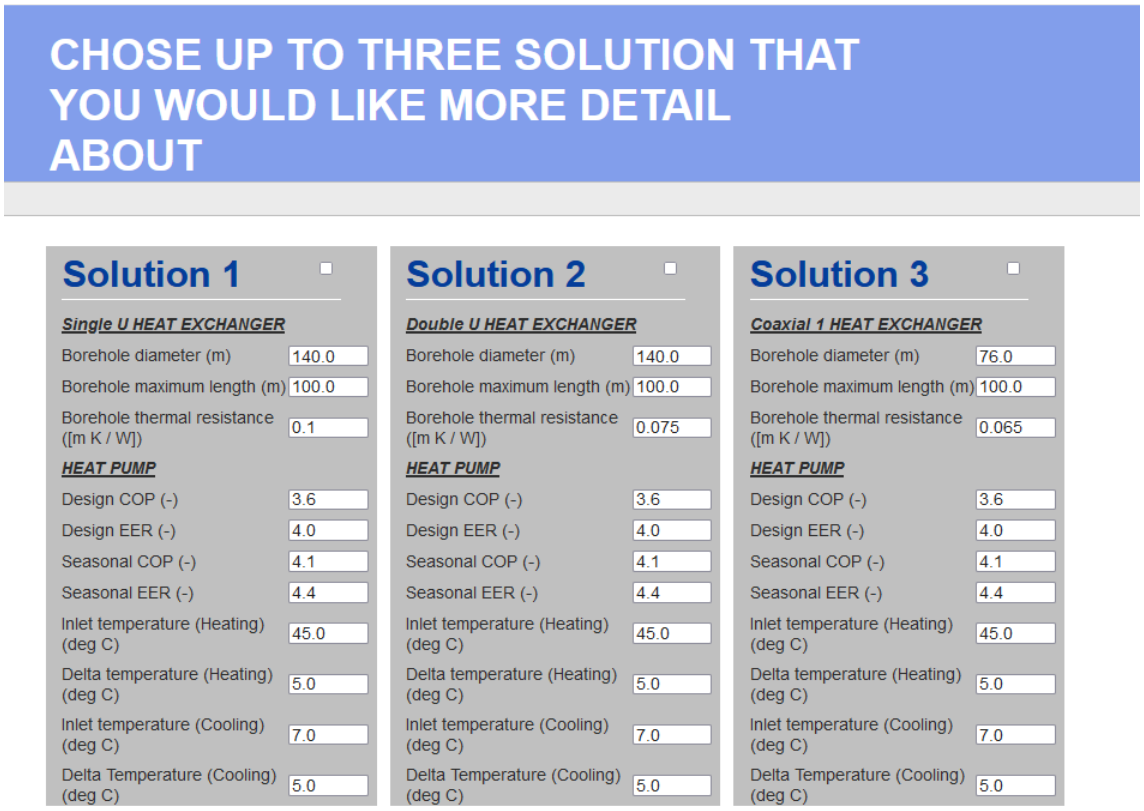


Figure 13. GEO4CIVHIC DSS Website - Solution preselection module

When customizing solution technologies, the following information can be modified:

- Heat Exchangers
  - Borehole diameter (m)
  - Borehole maximum length (m)
  - Borehole thermal resistance (m K / W)
- Heat Pumps
  - Design COP / EER
  - Seasonal COP / EER
  - Inlet and delta temperatures for heating and cooling (ºC)

In order to select a solution for the calculations, the user should click on the checkbox at the top-right of the Solution box. Only the selected solutions will be taken into account in the following steps of the process.

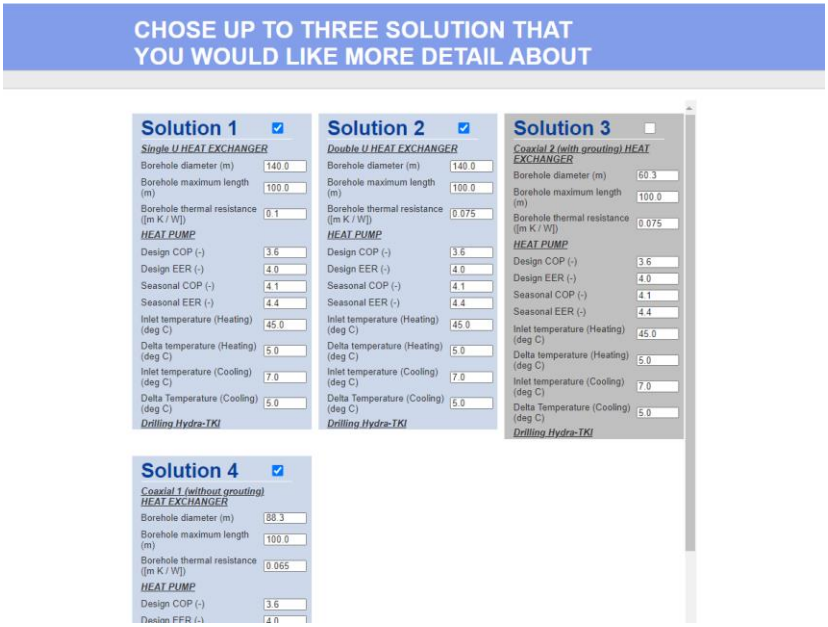


Figure 14. GEO4CIVHIC DSS Website - Selected solutions

2.5 STEP 4. GEOTHERMAL CALCULATIONS

After the solutions have been selected, the geothermal calculations take place. In this step, for each solution, the heat exchanger dimensioning must be evaluated.

The following information must be completed:

- Cooling length (m)
- Heating length (m)
- Installation surface (m2)

As it happened before, the system allows the users to enter their own values obtained through other means. If they do, they can fill-in the boxes and click on the “Save my values” button. Otherwise, they should click on the “Default values” button. In such case, the calculation of the Heat Exchanger dimensioning will be performed following the ASHRAE method.

Figure 15. GEO4CIVHIC DSS Website - Geothermal calculations

After the information is complete, the users should press the “Next” button, to access the next phase of the process.

2.6 STEP 5. SOLUTION EVALUATION

The last step of the process is the solution evaluation.

The system evaluates the solutions according to different technical, environmental and economic indicators. These indicators are shown to the user arranged in different tabs for clarity, so users can compare the solutions according to these quantitative values.

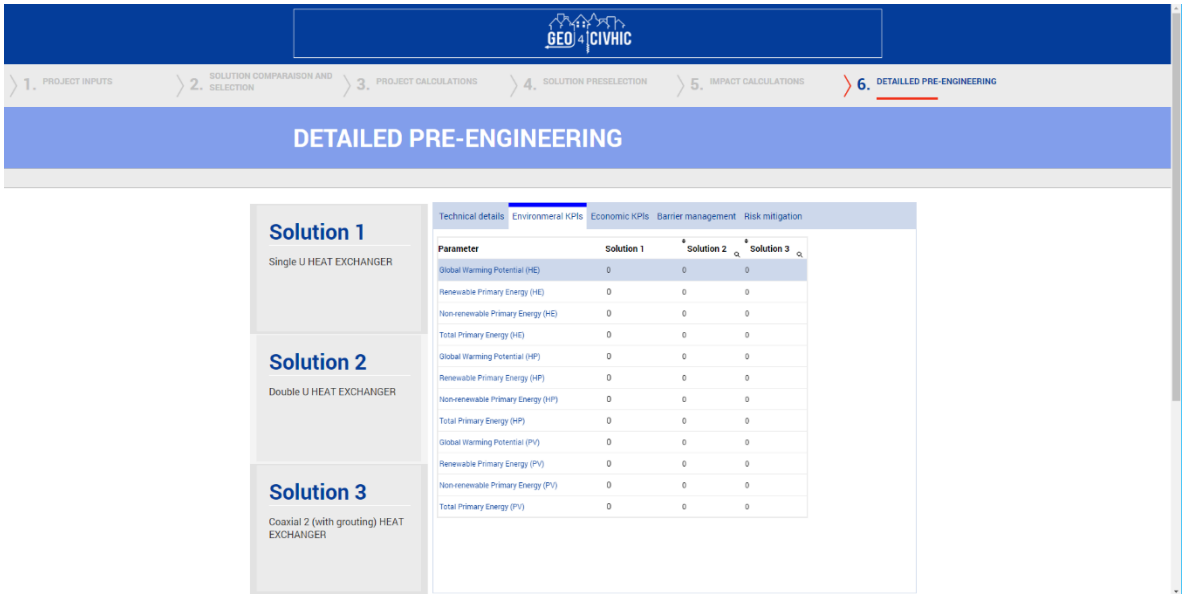


Figure 16. GEO4CIVHIC DSS Website - Quantitative solution comparison

Besides, some qualitative information is also presented to the user:

- The ***Barrier management*** tab presents information of those common barriers found in the installation of geothermal systems that can be applied to the current project, as well as the list of solutions to overcome them.
- The ***Risk mitigation measure*** tab presents the Risk Assessment for the project, including proposed solutions and mitigation measures.

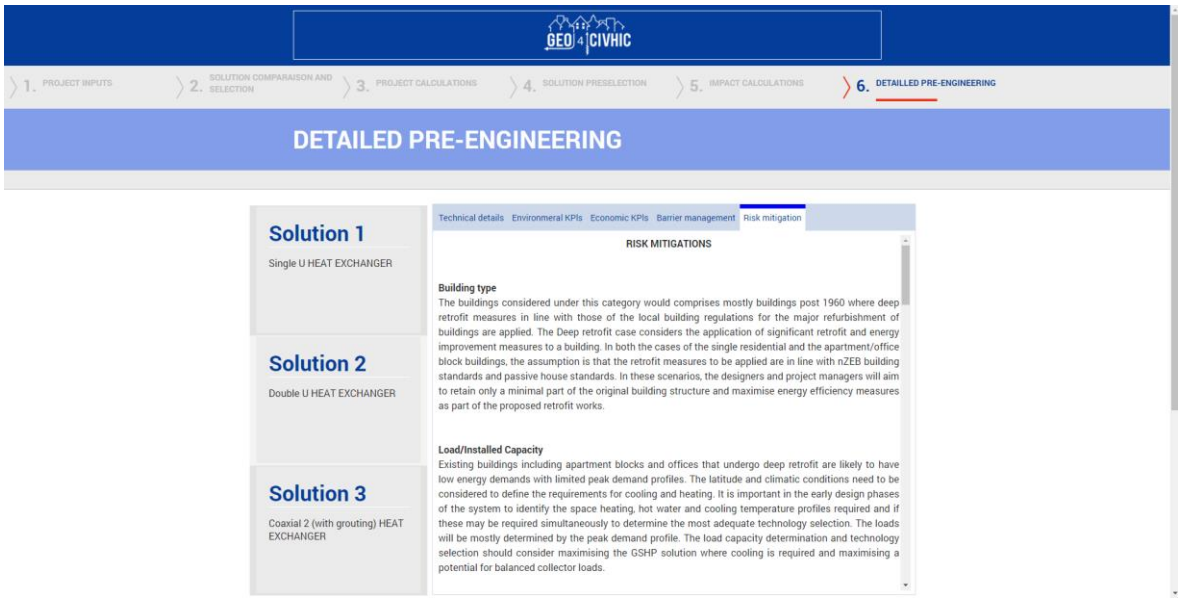


Figure 17. GEO4CIVHIC DSS Website - Qualitative information regarding the project

Conclusion

This document has presented the instructions for users to be able to employ the user-friendly DSS Website developed in the GEO4CIVHIC project. This web application enables users to access the DSS tool and evaluate and compare different geothermal solutions for their facilities.

The different steps of the process have been presented:

- Step 0: an initial step for managing user accounts and projects
- Step 1: the basic input introduction that defines the users’ facilities
- Step 2: additional information introduction, which corresponds to the climate and energy demand
- Step 3: the preselection of solutions and definition of the technologies involved
- Step 4: the geothermal calculations with the dimensioning of the heat exchanger installations
- Step 5: the final step, in which the solutions are evaluated and can be compared

These steps cover the whole process followed by the user from the registering in the website to the obtaining of final results.