SAPHEA
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

White book of the spatial dataset related toolbox

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1 OVERVIEW

The SAPHEA whitepaper briefly describes the planned functionalities and contents of the decision support toolbox. It also refers to the user requirements and contains a preliminary general data management plan. It also serves as a guidance for the further development of the SAPHEA decision support tool. The white book and the tool development procedure follow the agile (software) development procedure and therefore, could be adapted through the development process based on the priority of user needs, data availability, technical limitations and resource availability.

2 FUNCTIONALITIES AND CONTENTS OF THE DECISION SUPPORT TOOLBOX

The final release of the Hotmaps toolbox is used as a starting point for the SAPHEA decision support toolbox. This version can be accessed via the following link: https://www.hotmaps.eu.

The tools developed for the SAPHEA will be (partially) integrated into the Hotmaps toolbox. Some of the future tool developments in the scope of the SAPHEA project will be done outside the Hotmaps toolbox but with attention paid on maximisng interaction and synergies among the different tools in order to provide a full decision support enviroment. As an example, the Gamebook will combine diverse sources of information and knowledge (fact sheets, self-assessment questionnaires and Hotmaps data) in order to support the design and implementation of geoHC networks from the very early stage of the decision-making process.

The following sub-sections present the platform's general functionalities and new developments for the SAPHEA decision support toolbox.

2.1 Graphical User Interface

The client graphical user interface (GUI) will be the only visible component of the toolbox for the end-user. **It is important to mention that certain aspects of the GUI may change and improve to cover the requirements of the SAPHEA users better**. Therefore, the presented GUI may not be considered as the final version.

Once the toolbox is opened, the disclaiming page is shown as depicted in Fig. 1. Besides the disclaimer message, additional information regarding the objectives of the Hotmaps toolbox, as well as the link to the Hotmaps project website and the data repositories, is provided.

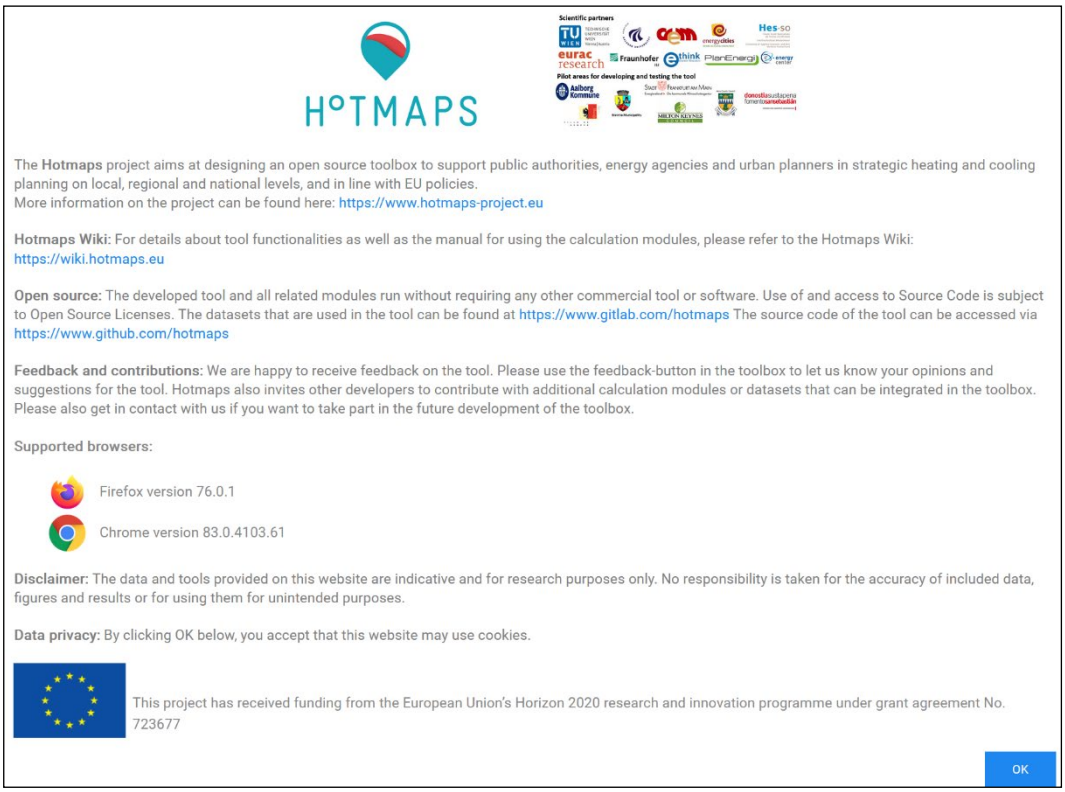

Fig. 1 Introduction to the toolbox and disclaimer

The Hotmaps GUI is a GIS-based interface. By closing the disclaiming page, the user encounters the map of Europe. By default, the heat demand density map of EU countries and NUTS 2 layer are depicted. In addition to these two maps, some tools and buttons can be seen in the GUI. These tools are illustrated in Fig. 2 and listed below:

1. "Go to place" to search for a location
2. Layers window
3. Selection tools
4. The "Show Results" window
5. Feedback
6. Save Session
7. List of saved sessions
8. Selection tools
9. Load results / Clear zone for user selection
10. Hotmaps Wiki
11. Zoom in/out
12. Selection of territorial scale
13. Selection of background map

Fig. 2 Navigation through the Hotmaps toolbox

Besides the heating and cooling-related datasets available on the Hotmaps toolbox, additional datasets gathered in the scope of the SAPHEA project will be integrated into the platform and illustrated on the GUI. The user can select different layers. Fig. 3 and Fig. 4 show two exemplary vector and raster layers depicted in the GUI. These figures show that each layer has a legend (symbology), information on the layer and download link.

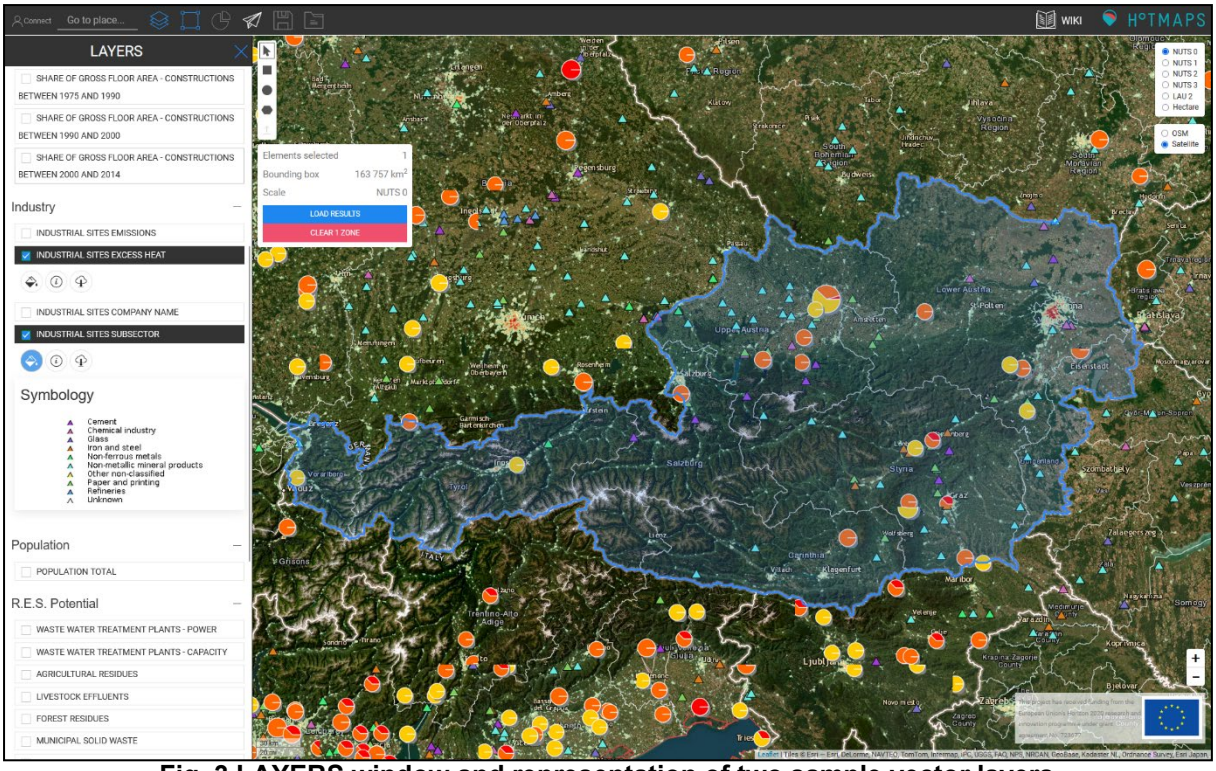

Fig. 3 LAYERS window and representation of two sample vector layers

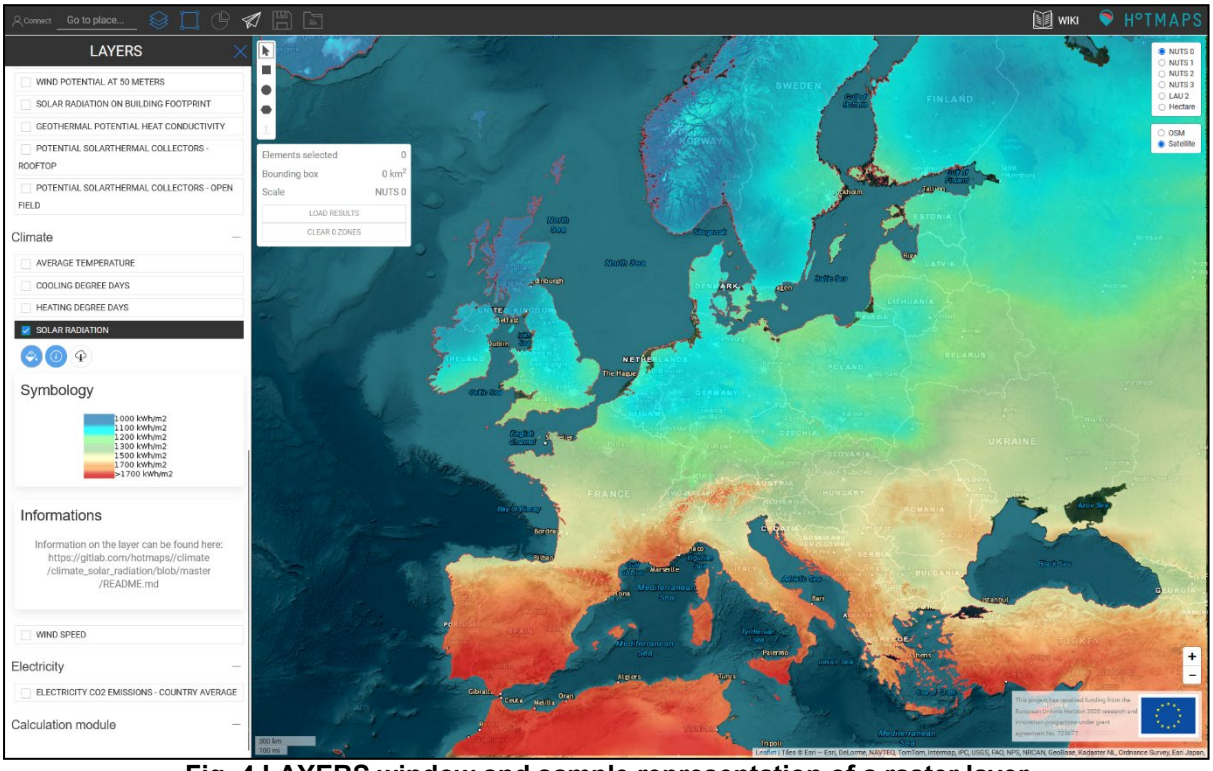

Fig. 4 LAYERS window and sample representation of a raster layer

After the area selection and depending on the choice of a layer, pressing the "LOAD RESULTS" button opens the RESULTS window. It presents the corresponding indicators

obtained from selected layers for the selected area. Inside the RESULTS window, the user can see the indicators (Fig. 5).

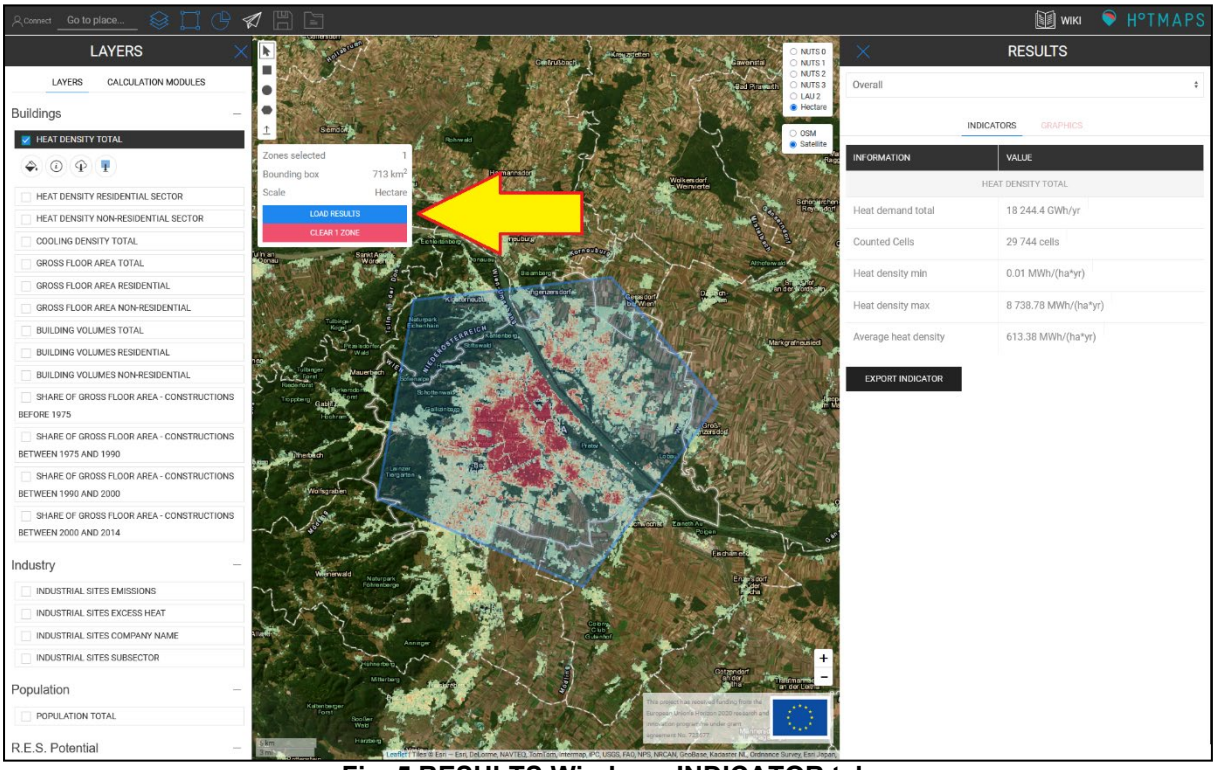

Fig. 5 RESULTS Window - INDICATOR tab

Following the selection of an area, the user can navigate to the "CALCULATION MODULE" tab under the Layer window. From there, the user may run various analyses. Each calculation module is provided with a short description of its functionalities and requires its own input parameters. The outputs are presented in indicators, diagrams or GIS layers depending on the calculation module. The user can see the outputs in the RESULTS or LAYERS windows. The user can add a name for each session to distinguish between different running sessions of a calculation module.

The SAPHEA decision support tool, specifically the GEOPHIRES (look at section 2.2), will appear under the calculation module tab. For this purpose, the GEOPHIRES tool will be modified, adapted to the requirements of the SAPHEA users and integrated into the Hotmaps toolbox.

Fig. 6 to Fig. 9 show how to select a calculation module and get the results. Here, the calculation session was named as "Test Run". The session name appears in the RESULTS window in the INDICATOR and GRAPHICS tab. Furthermore, the output layer of the calculation module appears in the LAYERS window.

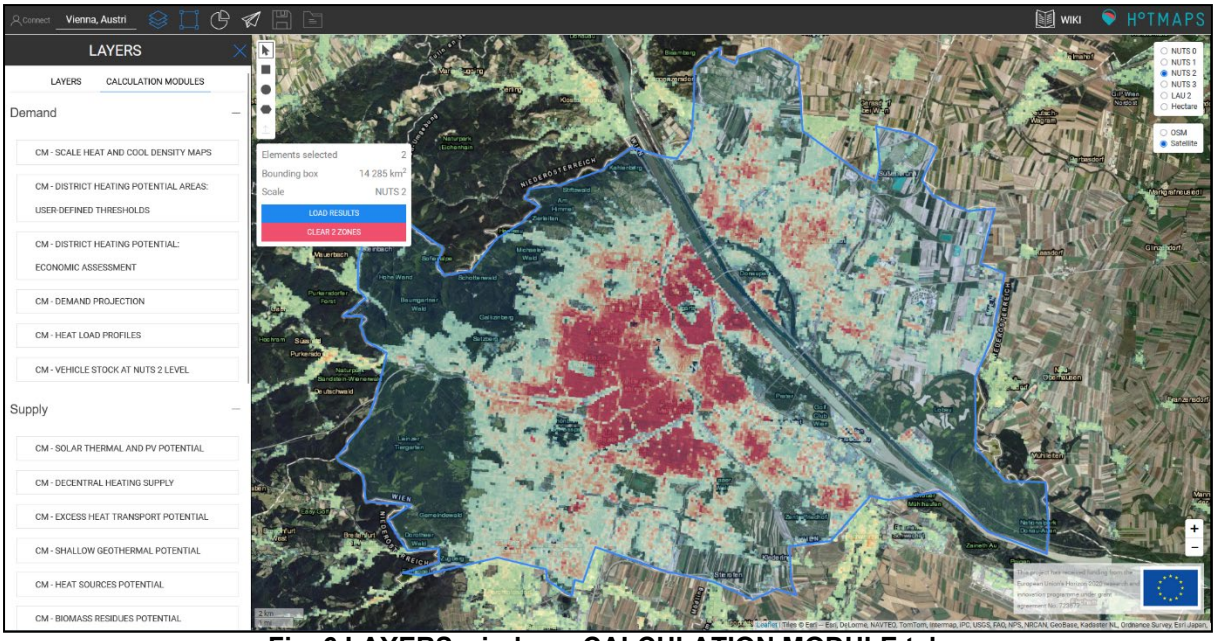

Fig. 6 LAYERS window - CALCULATION MODULE tab

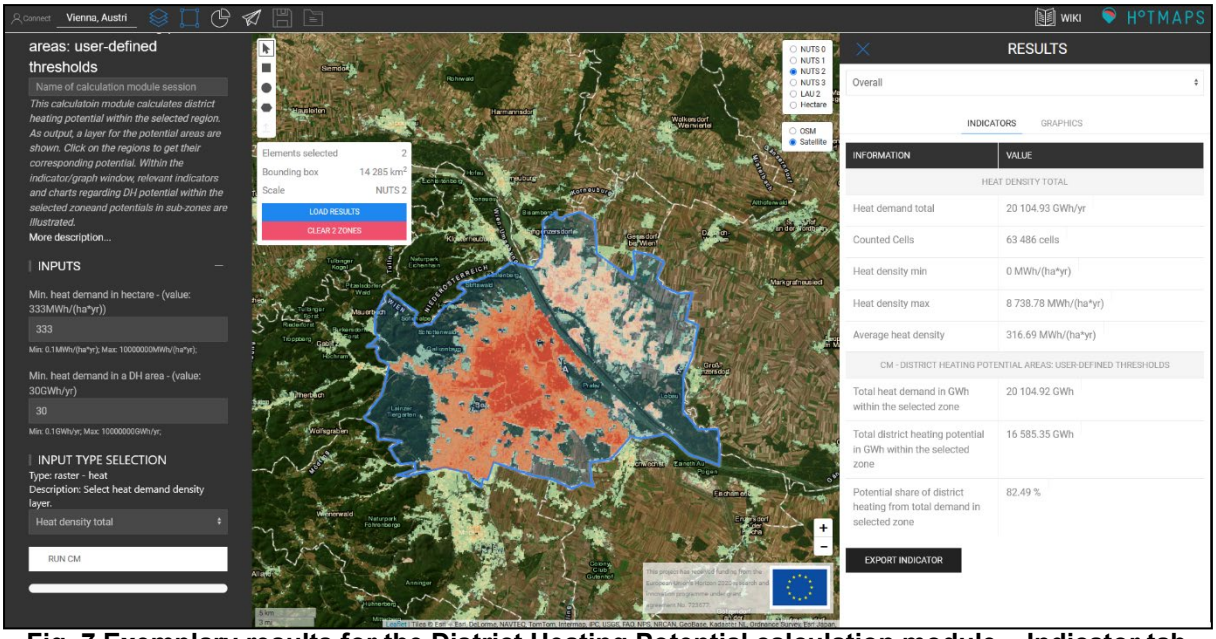

Fig. 7 Exemplary results for the District Heating Potential calculation module – Indicator tab

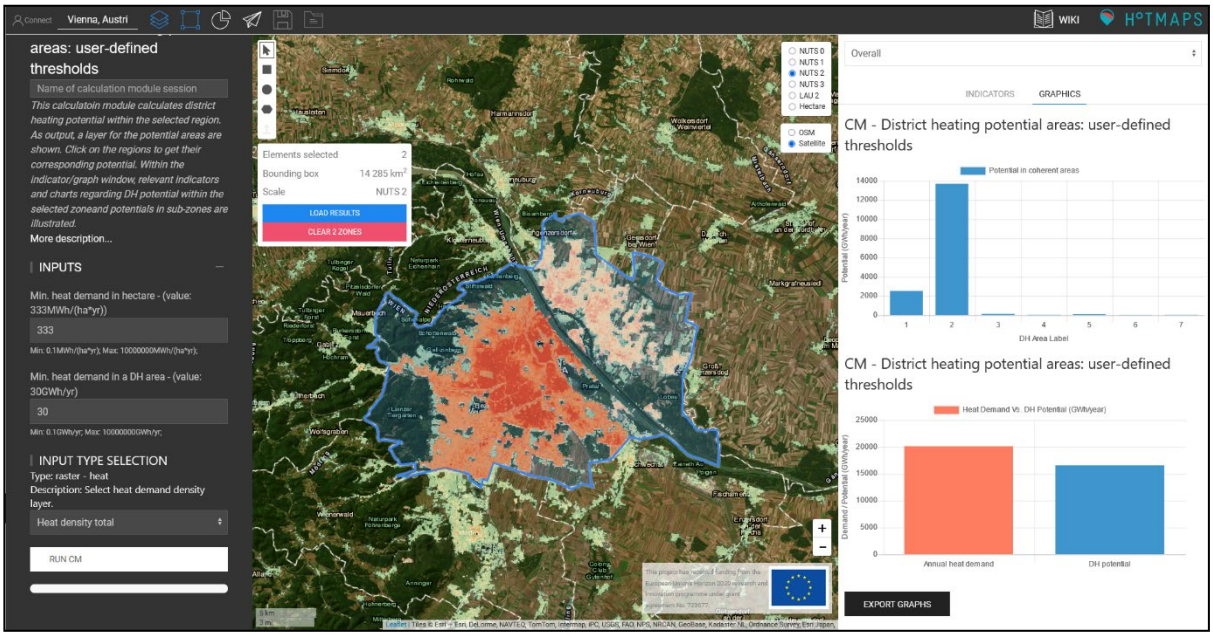

Fig. 8 Exemplary results for the District Heating Potential calculation module – Graphics tab

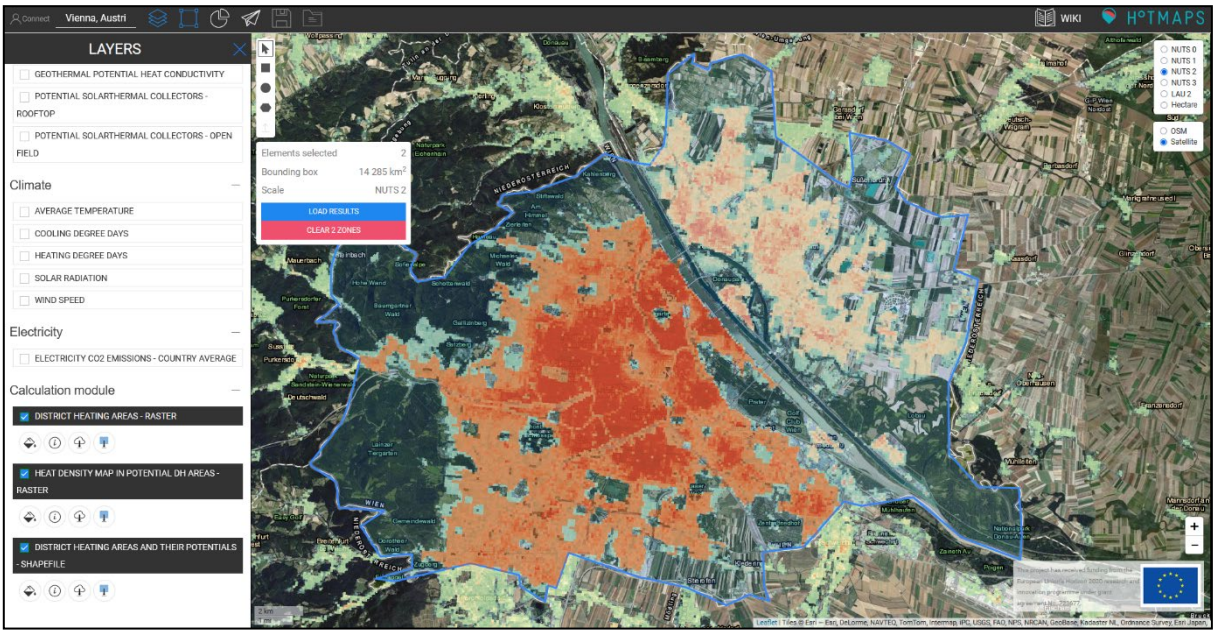

Fig. 9 Output layer of the calculation module in the LAYERS window

2.2 Decision support tool

The decision support tool is composed of two main parts:

- Gamebook
- GEOPHIRES

The gamebook is used for the first movers in the field to get insight into geothermal-based district heating systems. It can also be used for strategy developers to get insights into a region's geothermal-based district heating systems.

The GEOPHIRES, on the other hand, addresses the needs of experts with geothermal know-how. It combines engineering models of the reservoir, wellbores, and surface plant facilities of a geothermal plant with an economic model to estimate the capital, operation and

maintenance costs, lifetime energy production, and overall levelized cost of energy. The existing version of GEOPHIRES (https://doi.org/10.1186/s40517-019-0119-6) is expanded, and spatial aspects are added to the tool to be able to automatically query spatial default data based on the user selection on the map. Subsequently, GEOPHIRES will be integrated into the Hotmaps platform. The default data sets on Hotmaps provide the required spatial data. Where data is not available, assumptions shall be made, or the user should provide data.

An agile tool development process will be followed in the development of decision support tool. Accordingly, the tool will be adapted to the user-requirements, technical limitations, resource availability and data availability.

3 USER REQUIREMENTS

The user requirements are studied and considered in two phases. In the first phase, a closed version of the decision support too is provided for the testing to the consortium experts. Following an internal workshop, the consortium experts provided their expectations and feedback to the decision support tool. Currently, the following aspects have been addressed by consortium members:

- **User-Friendly Interface**: The tool should have an intuitive and user-friendly interface that allows users with different levels of technical expertise to easily navigate and utilize its features. Accordingly, the Gamebook and GEOPHIRES are prepared for target groups with different expertise levels.
- **Data Input and Validation**: While the default data set should cover data required for the analyses, users should still be able to input relevant data, such as geological information, well parameters, and heat supply or demand profiles. The process for the default data sets should include data validation checks to ensure accuracy. We will rely on relevant, publicly accessible geoscientific, technological, pan European datasets. Datasets will be processed based on the workflows defined in the project.
- **Geological Data Visualization**: Users may need geospatial data visualization tools to understand the geological characteristics of the potential geothermal field. This will be provided to the user based on the available Hotmaps infrastructure and functionalities.
- **Economic Modeling**: At least for the expert users, the tool should provide economic modelling capabilities, including calculations for capital costs, operating expenses, and possibly revenue projections. Users should be able to adjust assumptions and scenarios for sensitivity analysis. This aspect will be addressed among all by GEOPHIRES.
- **Heat Demand Analysis**: Users should be able to input heat demand data for the intended area of heat supply. The tool should allow for calculating the heat production and consumption balance and roughly allow for an assessment of the project feasibility based on this demand. This will be ensured via the integration into the Hotmaps toolbox, which covers this heat demand analysis in its current version.
- **Resource Assessment**: The tool should incorporate geothermal resource assessment capabilities, including temperature gradient analysis, reservoir size estimation, and heat extraction potential. This is essential for determining the

feasibility and sustainability of the geothermal resource. However, we should rely on available data or assumptions where data is rare.

- **Cost-Benefit Analysis**: Users should have access to cost-benefit analysis features that allow them to compare the economic viability of geothermal heat supply via district heating against the decentral heat supply option. This will be done partially using the existing functionalities and modules in Hotmaps.
- **Risk Assessment**: For expert users, the tool should allow for performing risk assessment. The open-source tool will allow expert users with programming knowledge to build on the available functionalities and perform sensitivity analyses.
- **Scenario Analysis**: Users should be able to create and evaluate multiple scenarios to assess different development options, such as varying well depths, heat distribution networks, and financing arrangements. The scenarios will be developed under Task 2.2 and will be addressed in the decision support tool.
- **Reports and Documentation**: The tool should generate reports summarizing the economic assessment, including key assumptions, results, and recommendations. Users should be able to export these reports for documentation and presentation purposes. Hotmaps toolbox allow exporting the results in form of GIS layers or CSV files.
- **Integration with GIS and Databases**: Integration with Geographic Information Systems (GIS) and relevant databases can enhance the tool's capabilities by providing access to geospatial and geological data. Thanks to the Hotmaps platform, this should be achieved with limited effort.
- **Accessibility and Security**: Ensure the tool is accessible from various devices and browsers while maintaining robust security measures. For this purpose, professional IT developers will maintain the Hotmaps platform.
- **User Support and Training**: Provide user support resources and training materials to help users make the most of the tool and troubleshoot any issues. This will be followed in the Work Package 6 of the project: “Capacity building and stakeholder interaction to support future uptakes of geoHC networks in European regions”.
- **Updates and Maintenance**: Regularly update the tool to incorporate new data, technologies, and best practices in geothermal field assessment and economic modelling. This will be followed through the project.

The second round of tool improvement and consideration of the user requirements will be done after workshops and by gathering user feedback. The feedback will be prioritized and implemented in the final version of the decision support tool.

Besides these two steps, the feedback button (Fig. 10) in the toolbox is a medium for direct contact with the tool developers at any time.

Fig. 10 Feedback button

4 PRELIMINARY GENERAL DATA MANAGEMENT PLAN

The SAPHEA data management plan has been concluded in Deliverable 1.3. This section provides a brief explanation of the data management for the default data sets in the toolbox.

Fig. 11 describes the data integration process, which allows filling up the data warehouse in order to have data ready on the toolbox.

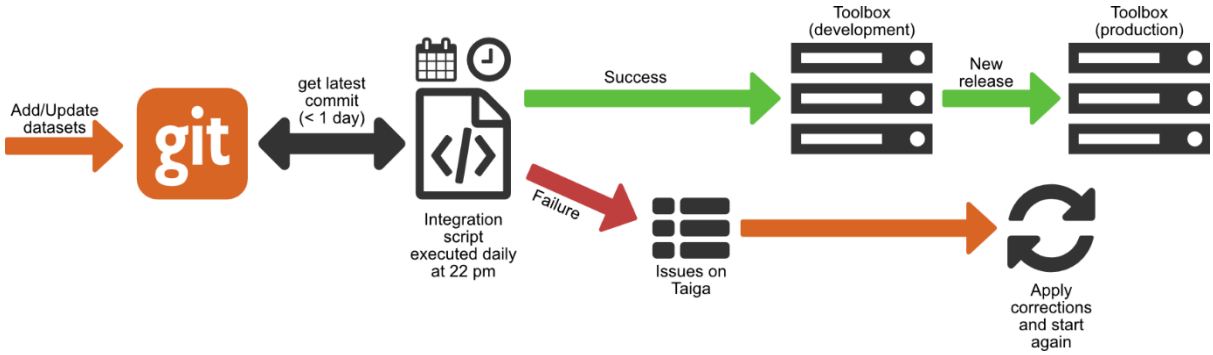

Fig. 11 Data integration process

A data warehouse is the way to handle and analyze data sets. In order to handle the different functionalities such as displaying data, allowing users to access the default data sets, and deriving indicators, the following systems and technologies are used:

- Git **repository:** providing version control, a data stores metadata for a set of files and directories that facilitates collaboration on software development,
- PostGIS database provides spatial objects for the PostgreSQL *database*, allowing storage and query of information about location and mapping,
- GeoServer: an open-source server for sharing geospatial data.

4.1 Git repository

The Git repository is the first-level database and the entry point of all datasets used in the Hotmaps toolbox. The repository is where a default dataset is stored with an open-source license, and anyone can retrieve any dataset published there. The dataset providers add data in a Git repository. For each dataset added to Git or updated, the automatic integration server will run a process to update the toolbox and show the most recent data version.

4.2 PostGIS database

Uploaded data sets to the Git repositories are automatically transferred and saved in the GIS database. The GIS Database is responsible for storing data. Fig. 12 below shows the structure of the GIS database. In the database, two types of data are stored:

- The raster data are directly stored in the database and are only used to derive indicators at the hectare level. However, for LAU2 and NUTS 0 to NUTS 3, pre-calculated tables are generated from raster data to optimize request speeds.

- Vector data sets include tabular data attributed to the administrative boundaries like LAU 2 or NUTS 0 to NUTS 3.

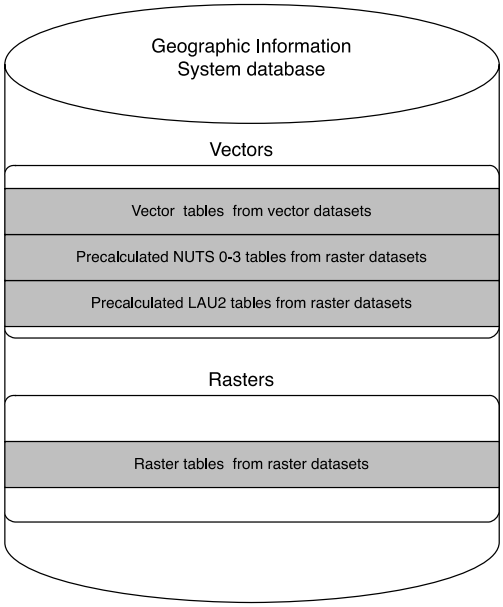

Fig. 12 GIS database

4.3 GeoServer

The GeoServer is used to store the data that are displayed on the toolbox. It produces maps that appear in the user interface of the toolbox. The vector data are imported directly from the database. Raster files, on the other hand, are integrated into the GeoServer.