LOw Carbon After Life: sustainable use of flooded coal mine voids as a thermal energy source - a baseline activity for minimising post-closure enviromental risks

LOCAL

Research Fund for Coal & Steel

LoCAL Deliverable 3.4

Toolbox assuring multiplication of the project results

WP number	**WP 3**
Partner responsible	**GIG**

GIG

Deliverable 3.4

Elaborated within tasks 1.1, 1.2, 2.1, 2.2, 3.2, 3.3 tools and algorithms were combined as a one toolbox gathering all utilities for mine waters heat extraction.

Elaborated tools were characterized and categorized within Toolbox, with full description and manuals. Such approach will allow to multiplication solutions for preliminary studies at sites that gives opportunity to heat extraction from mine waters.

Toolbox

LoCAL Project Toolbox, is a web page space containing all utilities elaborated within LoCAL project. All tools are categorized in three categories: **Science, Engineering** and **Economy**. So represent three switches, were user can find specific tool description, button for its download and button for manual download.

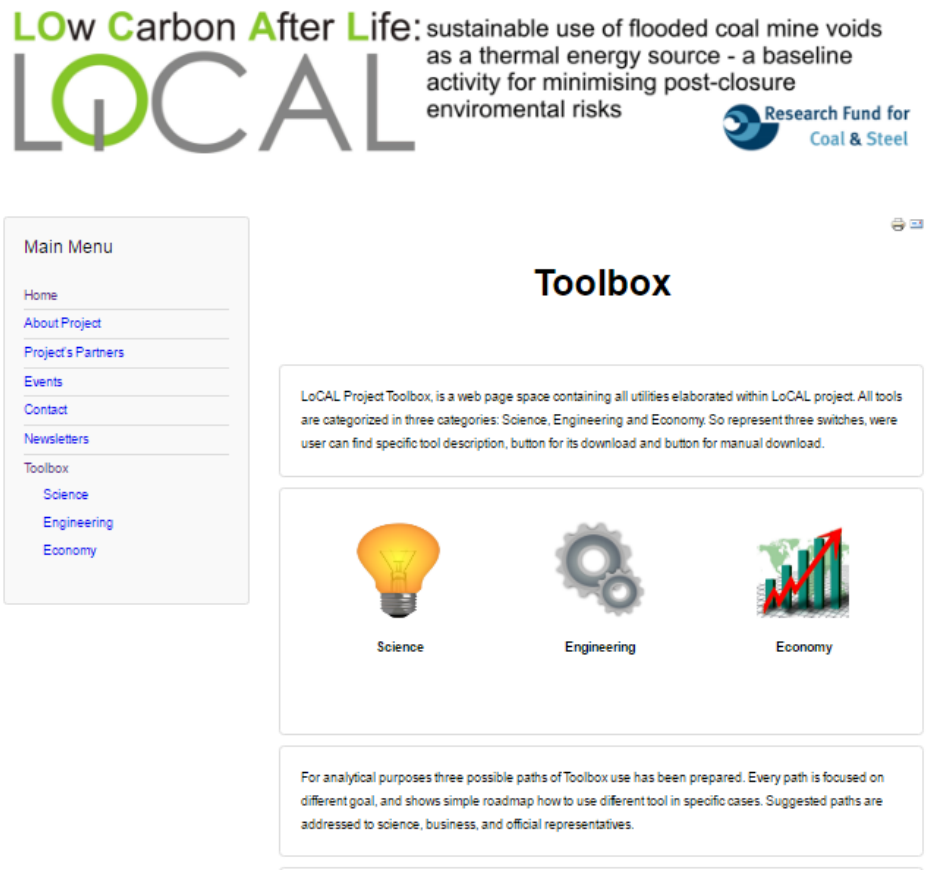

Figure 1. Toolbox start page (http://local.gig.eu/index.php/toolbox)

Toolbox is free and available at the internet address **http://local.gig.eu/index.php/toolbox.**

Science

Pumped Abstraction-Artificial Recharge tool and Pumped Abstraction-Natural Recharge tool

The new tool LoCAL-PAAR (Pumped Abstraction - Artificial Recharge) gathers together the flow skills of EPANET with the thermal skills of Rodriguez and Diaz model under a spread sheet that runs a macro code. The tool allows to estimate the outcoming temperature of the flow is crucial for geothermal aplications of the mine water.

Figure 2. Icon symbolizing access to scientific tools

LoCAL PANR is built in an excel workbook that interacts with the users by means of 4 sheets which can be activated or deactivated depending on the options selected. This tool, which has been called LoCAL PANR (Pumped abstraction - Natural recharge), constitutes a heat transfer calculator addressed for scenarios of an underground mine whose water is being pumped with a geothermal purpose. At these scenarios, the heat is extracted from or dumped into the pumped water and consecutively, the water is disposed of to a surface water.

LoCAL - PAAR fits for scenarios where, after the reinjection, the minewater flows through a network of galleries exchanging heat with the surrounding rock mass. The aim is to calculate the temperature of the mine water at the abstraction point which will strongly depend on the itinerary and the dynamics of the fluid.

PANR (Pumped abstraction - Natural recharge) is a heat transfer calculator addressed for the scenarios of an underground mine whose water is pumped with a geothermal purpose. The heat is extracted from or dumped into the pumped water and consecutively, the water is disposed of to a surface water. At this scenario, there is no deliberate reinjection of thermally spent water.

Below fig x are shown two icons, the one with green arrow pointed down is for downloadig a proper tool, and the blue icon with letter “i” inside is for downloading a user manual for the tool

Figure 3. Icons for downloading tool, and manual

The icons for downloading tools and manuals are the same and works the same in every category so it will be mentioned only one no example of scientific tool.

Engineering - Cooling/heating tool

The objective of this tool is to consider the various configurations by which cooling provision can be integrated into mine water-sourced geothermal heating systems, both passively (without the use of heat pumps, but merely by natural temperature gradients) and actively (using heat pumps).

Figure 4. Icon symbolizing access to engineering tools

The concept of passive cooling implies the removal of waste heat from a building or industrial process without the use of mechanical chillers or heat pumps. The tool contains three model that allows to simulate conditions as follows:

- Model 1. LoCAL 3.3.1_Active heating or cooling tool.xlsm. This model simulates the incorporation of cooling into active (heat pump-driven) systems. The model simulates both heating-dominated or cooling-dominated systems.
- Model 2. LoCAL 3.3.2_Passive cooling tool.xlsm. This tool simulates both straightforward passive cooling performed by mine water, and the incorporation of an element of passive cooling into an active cooling / heating system.
- Model 3. LoCAL 3.3.3_Discrete heating and cooling arrays.xlsm. This model simulates the use of "chillers" and heat pumps performing heating simultaneously in a system.

Engineering - Cooling/heating tool

As part of the project it has been developed an analytical model (interactive tool for investors) that allows to analyze the cost-effectiveness of thermal energy use from mine waters. The model focuses on the technical possibilities of using mine water for the thermal energy purpose, the financial aspects of the reality of the investment implementation and its profitability, as well as on the identification of economic and environmental reasons, which speak of the ultimate profitability of the investment.

Figure 5. Icon symbolizing access to economical tools

Created tool allows to conduct the first step analysis on the basis of questions (interview with a potential investor), to show that the recovery of heat from mine water is or isn't possible in the region. First evaluation is obtained in a simple way (based on the "traffic light") and indicates if the investment is feasible and which items can hinder or completely prevent the construction of the installation. After a preliminary analysis of the results and obtaining positive evaluation for to possibility of carrying out the investment, user must enter additional data. These data are necessary for further financial analysis, together with an indication of the environmental benefits and economic realization of the investment. The user obtains information about the real cost of operating the system to generate the assumed amount of thermal energy. The user obtains information about the value of the DGC (Dynamic Cost Generation) indicator throughout the analysis period. User has the statement option of the result obtained in comparison with other available source of heat which can be founded as an alternative source of currently used energy. The user on the basis of environmental benefits analysis can assess whether the investment actually brings environmental benefits and, for example, despite the unfavorable financial results is indicated for realization even with no financial benefit. But in order to get a complete view of information to make investment, user can analyze the results of indicators for economic net present value (ENPV) and benefit / cost indicator (results of CBA - costs and benefits analysis).

Toolbox use – suggested pathways

For analytical purposes three possible paths of Toolbox use has been prepared. Every path is focused on different goal, and shows simple roadmap how to use different tool in specific cases. Suggested paths are addressed to science, business, and official representatives.

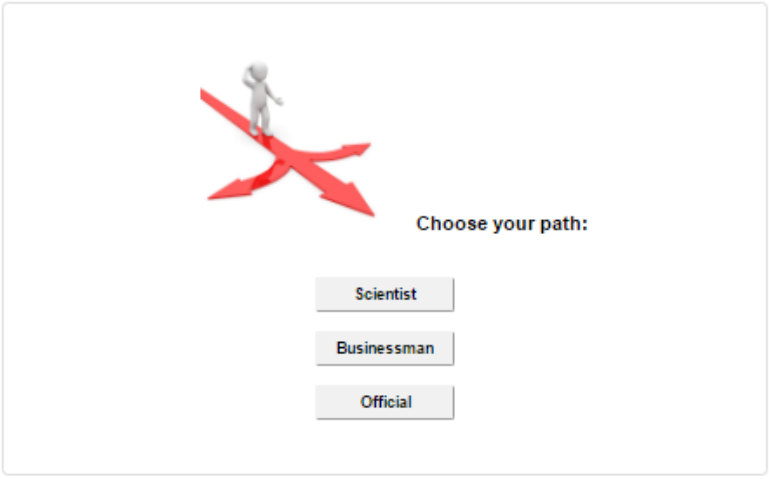

Figure 6 . Buttons for path selection

User needs to click on proper button, and then moves to the subpage with description and roadmap for selected path.

Scientist's path

Path suggested for scientist allows to make full use of elaborated tools. As a First step we suggest to use PNAR and PAAR tool, to understand and model heat transfer phenomena. If someone want's to go further in analysis can make use of engineering tool for heating/cooling process. For estimation of potential costs , economic tool will be useful.

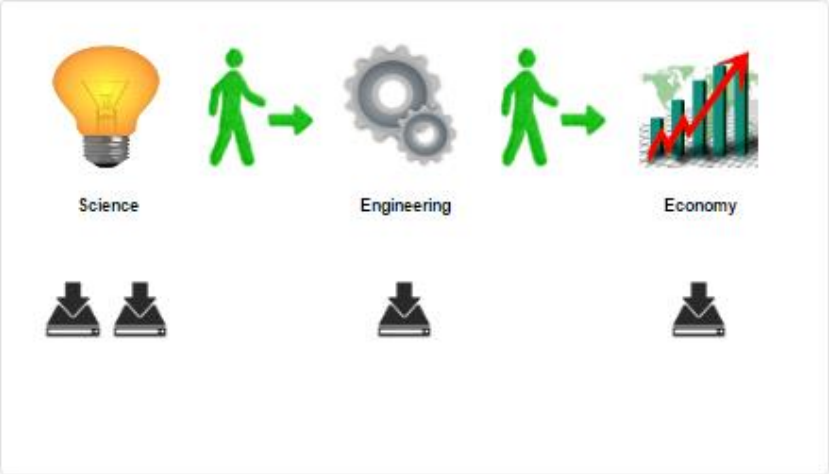

Figure 7 Roadmap for scientist's path

Pictures, below every picture symbolysing specific tool is aviable icon for direct download of the selected tool with no need to getting back to the tool main page. This mechanism works the same for every suggested path.

Businessman's path

Path suggested for business starts from interactive tool for investors (economy) and allows for fast indication of potential value coming from heat extraction from mine waters. Second step of analysis allows to go deeper in technical aspects of cooling and heating process .

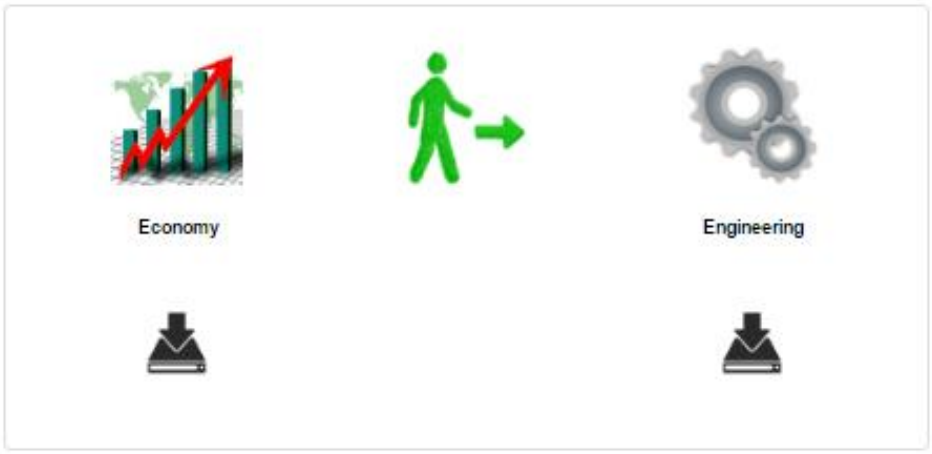

Figure 8 Roadmap for bussinesman's path

Official's path

Suggested path for officials focuses mainly on socio-economic aspects from interactive tool for investors with specific use of CBA analysis that allows to indicate environmental and social aspects of heat extraction from mine water.

Figure 9 **Roadmap for official's path**

Conclusions

Elaborated Project LoCAL toolbox (**http://local.gig.eu/index.php/toolbox**) contains all tools that were elaborated within the project. Use of html techniques made toolbox easy to access and wide spread set of practical knowledge that now is available for every person interested in heat extraction from nine waters. Making elaborated tools interactive with web page access makes them easy to use from every platform with net connection.