OpenLab P&A Leakage User Guide

Extended version 2026 with new Web Version
Version April 2026

OPENLAB DRILLING
NORCE

Contents

1. Information about P&A Leakage Calculator

The P&A Leakage Calculator of OpenLab is a response to the permanent plug and abandoned (P&A) wells that complies with the NORSOK Standard D-010 of knowing when a plugged well can have a possible leak. This is a solution can be formulated in term of the following quantity:

- The probability that the (permanent) barrier system will fail in a given time period

As part of developing a leakage risk model for permanently plugged and abandoned wells, a simple leakage rate calculator has been created to enable rapid assessment of a given well barrier solution. The tool provides a quantitative estimate of leakage potential by accounting for key leakage pathways, including flow through bulk cement, cement cracks, and micro-annuli along cement interfaces.

The calculations are based on NORCE´s computer models of leakage mechanics as also many years or research.

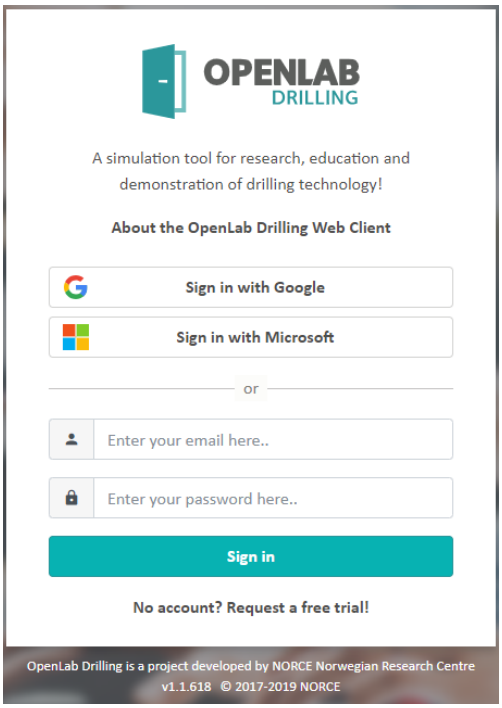
2. Account and Login

The P&A Leakage Calculator is accessible through leakage.build.openlab.app. To learn how to create an account, the following information is provided.

2.1. Create an account

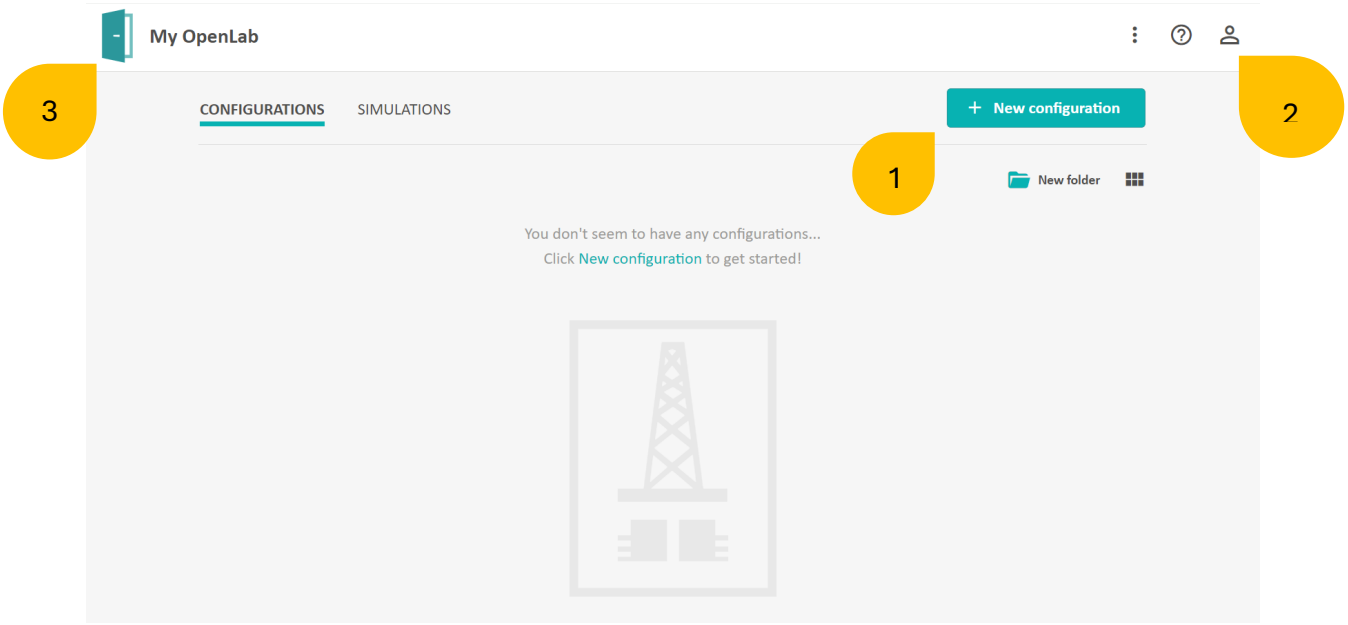
To create an account, start by navigating to https://live.openlab.app/ where you should see a form similar to the image below. In case of not being signed up earlier, you may use a Google or Microsoft account to request a free trail.

In order to unlock the full features, be able to simulate different wells simultaneously or having a full understanding of the leakage system, please contact us. More information about pricing or plans can be found in the following page.



2.2. Home page

After logging in, you will be directed to the Home Page which gives an overview of your Configurations and Simulations as seen in the following image.



Here you can create (1), move and delete configurations. In the top right corner, you will find your personal settings (2) and other user-specific information. You can always go back to the Home Page by clicking the OpenLab Icon (3) in the top left corner.

For the best experience, a Google Chrome Web Browser is recommended. It also runs on Edge, Firefox and Safari. However, some of the components might not work properly.

It is also possible to use the P&A Leakage Calculator at any screen size including a mobile device; however some functionalities are hidden for smaller mobile sizes.

3. Configuration

The P&A Leakage Calculator is designed to run simulations of the well, each of which requires a specific configuration. Each simulation is based on a distinct configuration that contains specific parameters that are added by the user.

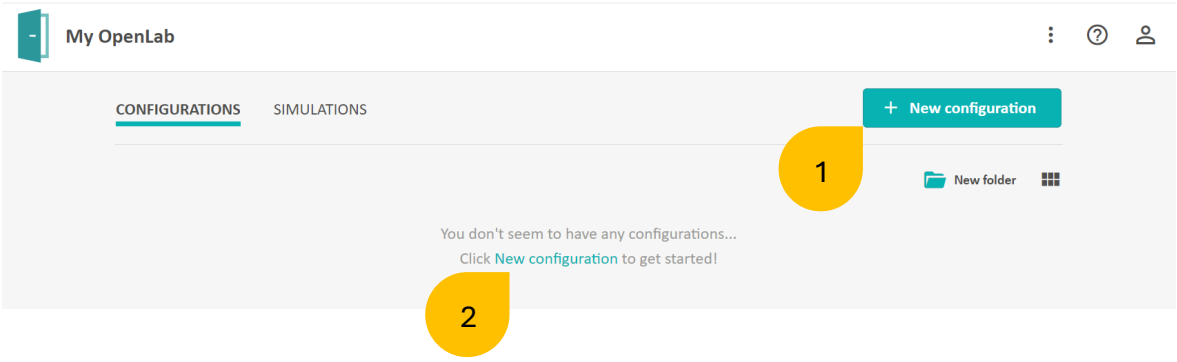
These input parameters are used by advance computer models to calculate the probability of a leakage by the Monte Carlo method. Because of the complexity of parameters, deterring the exact values for every component can be challenging for users. Nevertheless, this document explains the paraments that play the main role in the determination of leakage, giving the user a better understanding of the possible challenges and specifics of the program.

To simplify this process, OpenLab provides templates configurations that users can start from and modify as needed. Validation rules are built in to prevent unphysical setups or parameter values outside acceptable ranges.

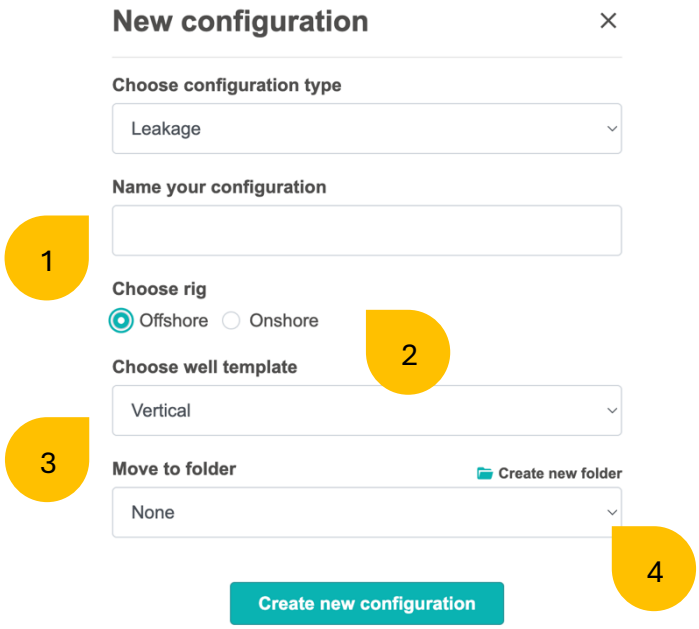
3.1. Create a configuration

A new configuration of a well can be created from the Home Page, or by editing any existing configuration.

1. To create a new configuration, simply click the “New configuration” button (1)(2)



The following image will appear as to designate the first configuration of the well



The new configuration window asks for four different parameters that the user has to fill in order to continue to the next step. These are:

1. **Name of the Configuration**
2. **Type of rig/well.**
    - Onshore or offshore
3. **Well template.**
4. **Move to folder.**
    - One can either choose a folder, create one or just ignore this part and save the configuration in the main menu.

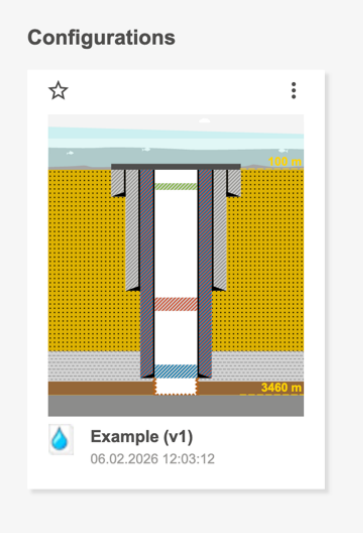
Once defined this values, one can click in the "**Create new configuration"** button and continue to the calculator

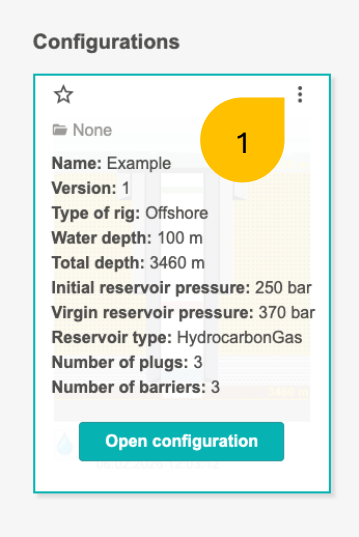
3.2 Configuration actions

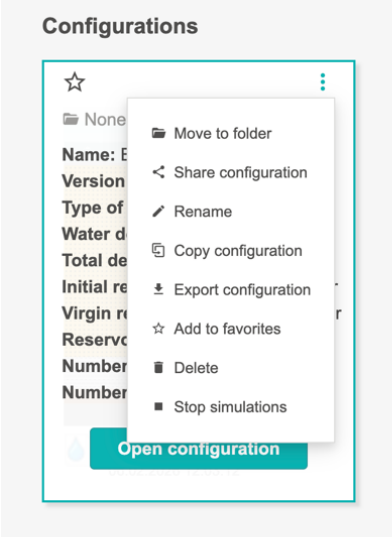
After creating a configuration, the well will be displayed in the main page as in the following images, where main information can be seen once the cursor is driven above the configuration or changed in the case of clicking on the three dots (1).

The menu that shows up is defined in order to make quick changes in the configuration such as:

- **Move to (defined) folder**
- **Rename**
- **Copy configuration, etc**.

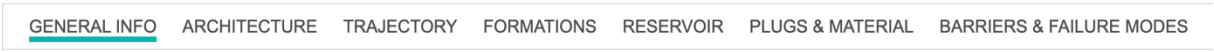






3.3 Edit a configuration

The configuration of a well can be done after one is created. This can be done after clicking on one of the configurations. The menu of the parameters that are possible to change are shown in the following image



In order to make changes and edit the values that the user is willing to do, by clicking on the parameter is enough to enter the menu and make changes in it. Each of the parameters can be explained in the following chapter

4. Categories in configuration

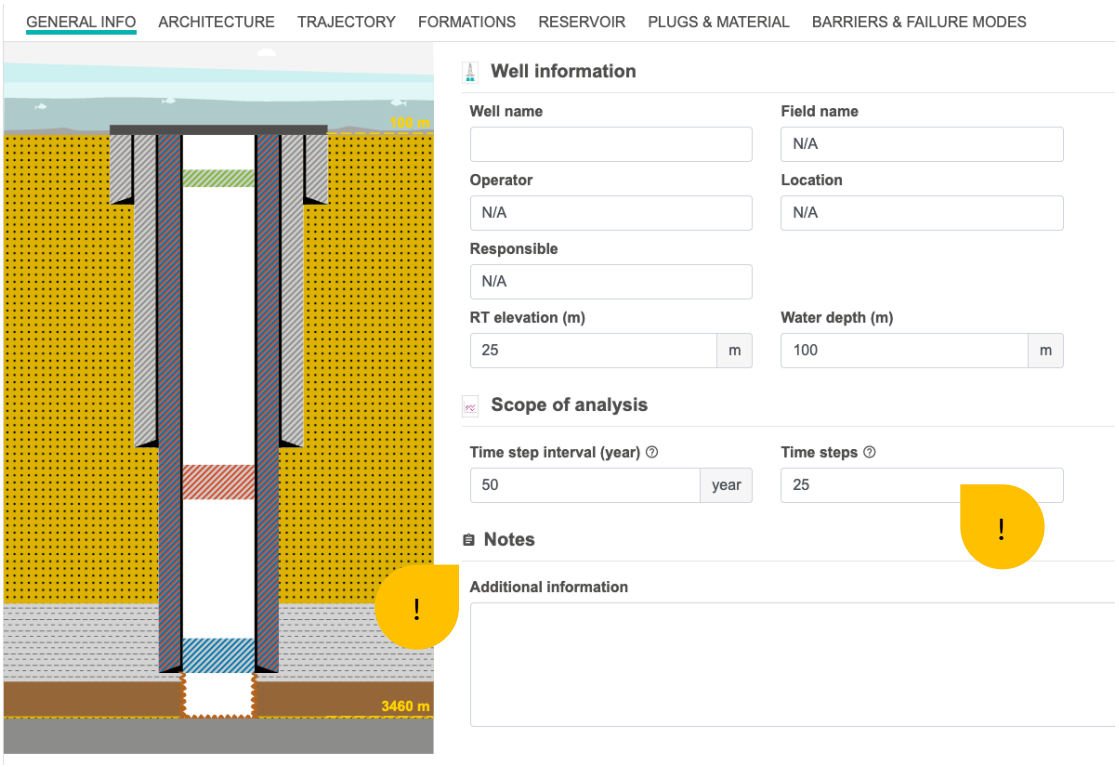
This chapter will represent the different sections and changes that the user has the opportunity to make in order to create the best assessment of the wells possible leaking failure. The categories are the following ones.

4.1. General Information

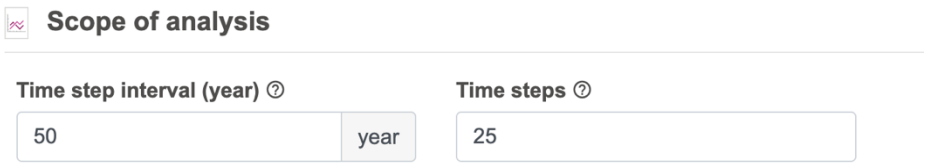
The first inputs are set so the user can add information to the well in order to make it easier to catalog it or make a better assessment of the well's identity.

The user can introduce the following information as the well information:

- **Well name**
- **Field name**
- **Operator**
- **Location**
- **Responsible**
- **RT elevation** (Rotary Table)
- **Water depth** (In case of the well being offshore)



In order to calculate the wells leakage there has to be a time limit for it to be calculated. This is described in the part **“Scope of analysis”.** Here the user can decide the number of years that it wants to calculate the leakage and the amount of steps it can be done in the span of “X” year in each step.



By definition the standard time for the program is 50 years with a time step of 25 years. Making it 1250 years in total.

The user also can add some information of the well such or some important value in order to clarify or better define the well in the “**NOTE”** area.

4.2. Architecture

The casing program is defined in this section. Here the user is able to edit and change the structure of the well. In order to do so, the user is given the freedom of adding or removing new casings into the system.

Casings in the well can be a minimum of 3 as per the simulator and as many as one desire. Each casing is defined by the following parameters:

- **Hanger depth**
- **Shoe depth**
- **Open Hole diameter**
- **OD (Outer Diameter)**
- **ID (Inner Diameter)**

These parameters define the only half of the casing that is in the well.

The system also needs to know the position of the casing and the material of the casing. This is defined also in each segment as the **Annular Segment**, where the user defines:

- **Start depth**
- **End depth**
- **Segment type** (It can be default or milled)
- **Material type** (Cement, Barite, Thermaset, etc)

In case of having a case made of different materials, the user can also make changes in the configuration by clicking on the + Add button.

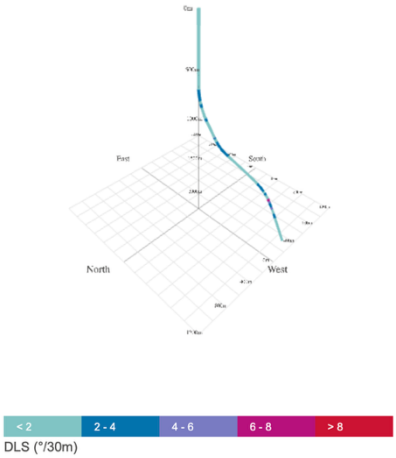
The user also can define the open hole from which the carbohydrate or gas was extracted making it closed or open. It also shares some of the parameters from the casing such as:

- **Start depth**
- **End depth**
- **Length**
- **Open hole diameter**

4.3. Trajectory

The trajectory consists of defining pairs of measured depths (MD) and true vertical depths (TVD) to define the wells path. The length of such and the underground shape of the well can be both added one by one by the user, “exported” (1) or “imported” (2) into a CVS file for a faster method.

In case of making changes, the rows can be erased but never moved. It is recommended to be precise. Difference in colors on the trajectory refer to the Dogleg Severity (DLS). In case of dogleg severity, an error will appear.



Survey stations

EXPORT IMPORT DELETE

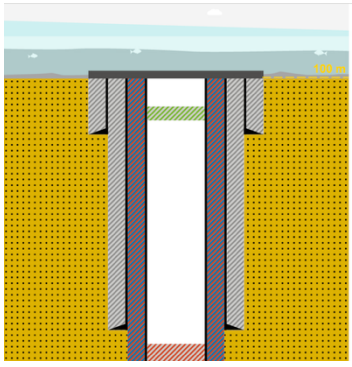
1 2

#	MD (m)		Azimuth (°)		DLS (°/30m)
1	0		0	0	0
2	43.5	0	0	43.5	0
3	152	0	40.6	152	0
4	291	0	360	291	0
183	2477.7	42.4	285.99	2102.9	2.1
184	2504.9	41.2	286.03	2123.2	1.32
185	2532.1	41.35	285.46	2143.7	0.45
186	2559.6	41.39	285.13	2164.3	0.24
187	2573.7	41.35	285.4	2174.9	0.39
188	2595	41.35	285.4	2190.9	0
189	2695	41.35	285.4	2265.9	0
190	2795	41.35	285.4	2341	0

+ Add

4.4. Formation

The formations sections are where the formations layers are defined. The standard architecture for the surrounding formations of the well are four different formation that extend to the reservoir.



Formations

DELETE

#	Name	Type	Mean top depth (m)	End depth (m)	Permeable
1	<unnamed>	Sandstone	100	2800	☑
2	Impermeable formation	Shale	2800	3250	☐
3	<unnamed2>	Other	3250	3450	☑
4	Reservoir	Sandstone	3450	3700	☑

+ Add

Each formation is defined in terms of the location of its top measure depth. However, the exact depth is unknown. Therefore, the top depth of each formation is represented by a probability distribution, which is used to reflect the uncertainty.

To define a probable value, it is used a specific distribution. This type of distribution is later used in other type of parameters and defined in Chapter 4.4.1.

The user is also able to change the rock type and choose from the different type of formations that can be found from the following list:

- **Chalk**
- **Claystone**
- **Coal**
- **Limestone**
- **Marl**
- **Mudstone**
- **Permeable basalt**
- **Rock salt**
- **Sandstone**
- **Siltstone**
- **Shale**
- **Other formations**

Once chosen the length and the mean top depth of each of the formations that the well is surrounded by, the user is also given the opportunity to make it **permeable** or not. This change that is located in the right part of each formation, allows to make a better understanding of the possible leakage through the walls of the plugs.

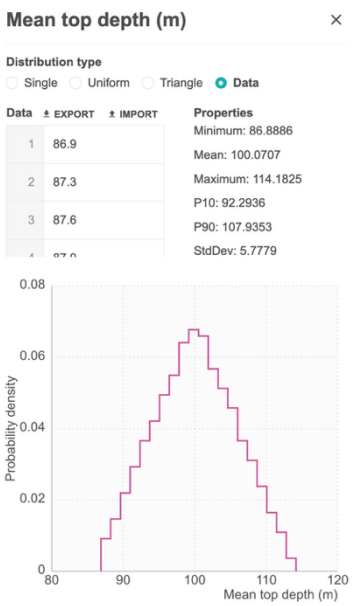
The materials that are permeable will be shown and defined in the reservoir category and those that are not, would be available to define in the last section. This **non permeable** formations would be defined in the barriers & failure modes.

4.4.1. Parameter distribution

Many parameters that have a shape in the left side as the picture below are uncertain parameters. They can be tuned depending on the distribution type of their value. The value can be changed by the user. This is changed clicking on the left icon in each of the properties as seen below.

After clicking on it, the user will be guided to a menu in order to choose the distribution type out of these:

- **Single**
- **Uniform**
- **Triangle**
- **Data** (the user can import and export data)

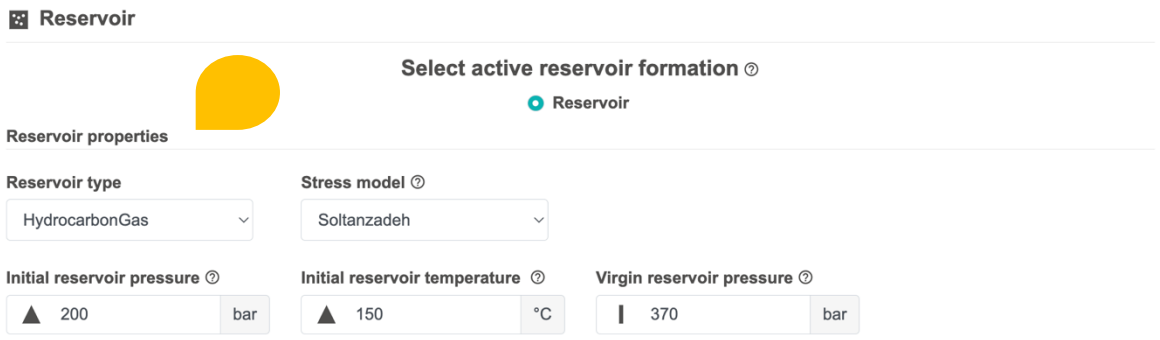


Depending on the distribution, one can set the distribution value in the limits one would like. It is also shown the properties as to have a better understanding and a more precise value for the user wants.

4.5. Reservoir

Once the formations that are permeable are defined in the previous section, the following configuration is based on the **reservoir formation**. As seen in the picture below, there are many parameters to be changed as the type of reservoir that is in the formation.

The main reservoir formations properties can be seen in the image bellow:



The reservoir type that are available in the simulation are the following:

- **Hydrocarbon / Gas**
- **CO2**

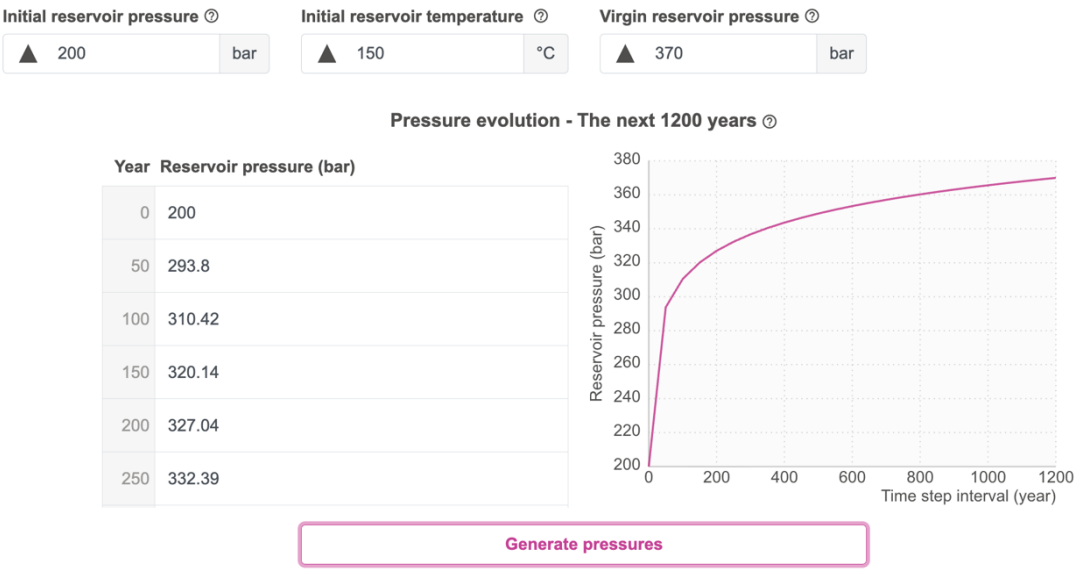
Later the reservoir has its own specific **stress model**, that is used in order to define the strain changes in the formation through the years under pressure. The stress models that one can choose are the following:

- **Soltanzadeh** (Standard)
- **Geertsma**
- **None**

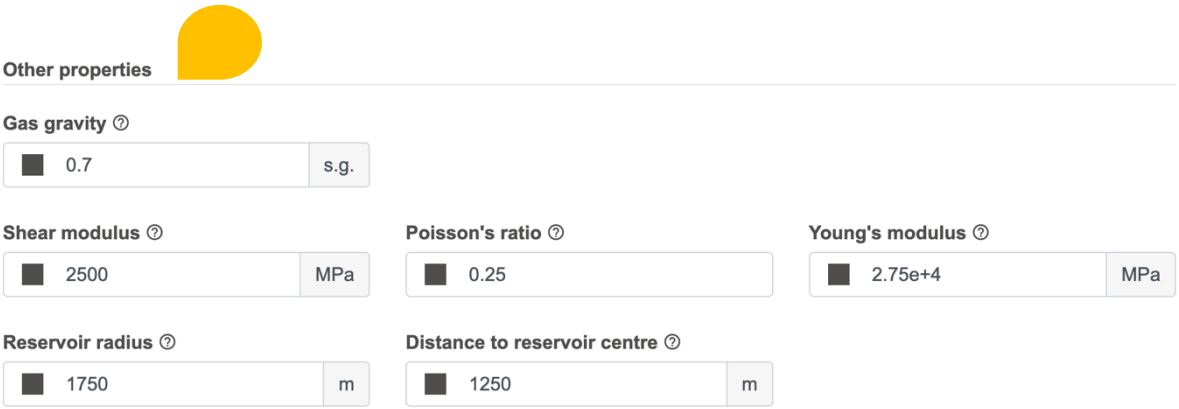
After deciding the type of stress model decided by the user, the following properties are necessary to define are the pressure evolution of the reservoir. The program calculates the pressure evolution of the reservoir based on this three conditions.

- **Initial reservoir pressure**
- **Initial reservoir temperature**
- **Virgin reservoir pressure**

The three parameters have their own distribution which is defined in Chapter 4.4.1. After setting their values, a graph that shows the pressure evolution though the years is displayed as the one below.



Lastly, this models then need to have defined the properties of the liquid that would be in each reservoir. When the user defines the stress model, the "**Other Properties"** of the model change accordingly to the chosen type. These characteristics can be seen in the following image.



Here the user has six different parameters with each one having its own distribution. They define the properties of the type of reservoir. The parameters are the following:

- **Gas gravity**
- **Shear modulus**
- **Poisson´s ratio**
- **Young´s modulus**
- **Reservoir radius**
- **Distance to reservoir center**

4.6. Plugs and Material

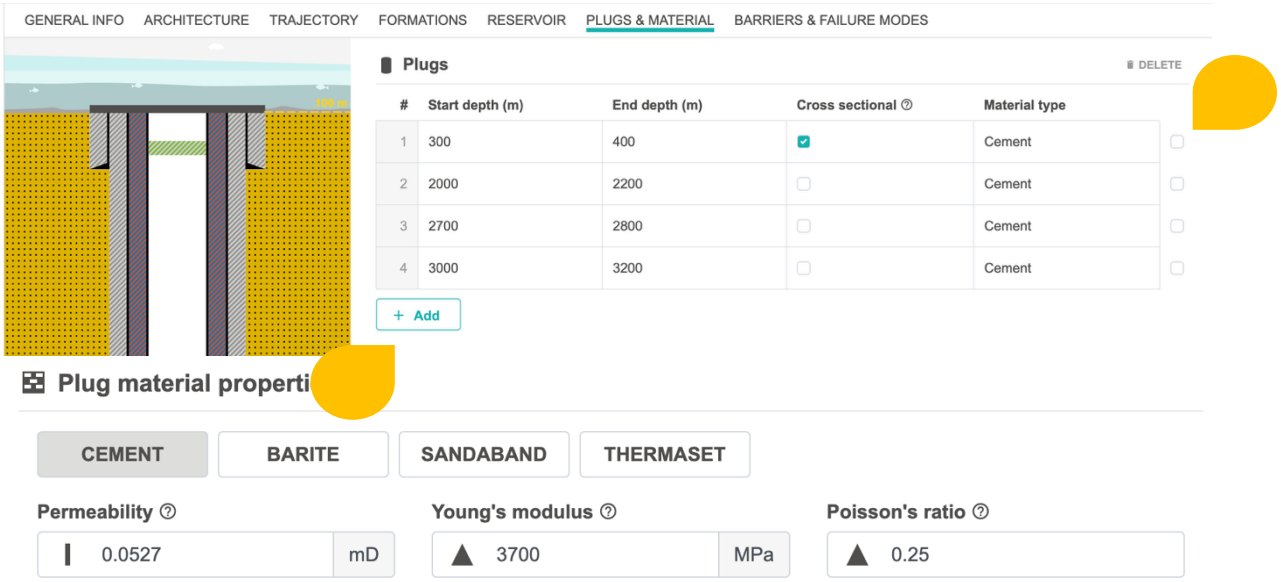
The plugs inside the well are defined here, in terms of their depth, either it is cross-sectional and the material of such. This is one of the many important parts of the well's behavior for the future possible leakages as it defines the points where it can fail.

First the plugs are given a definition in the wells structure by defining the position that it is located at. To determine that the user decides:

- **Start Depth**
- **End Depth**
- **Cross sectional**
- **Material type** (Cement, Barite, Sandbar, Thermaset and other)

One can delete different plugs in the right corner by clicking on the white box and then deciding which one to delete.

In order to add new plugs, the lower left side has a button that states 



After defining the shapes and lengths, one can define the properties of the materials that can be used as seen in the image above. This are defined by three characteristics:

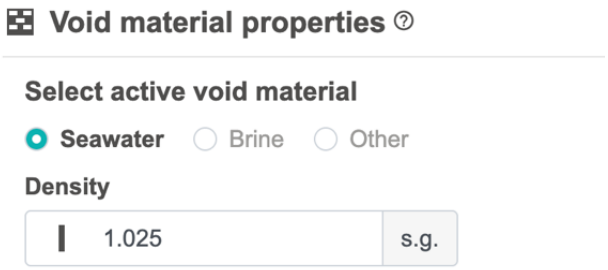
- **Permeability**
- **Young´s modulus**
- **Poisson´s ratio**

Cement is the only one that is defined from the beginning. The user has to define thew rest of them as per Barite, Sandband and Thermaset.

All of the parameters can be defined based on the Chapter 4.4.1

Lastly the void material or the fluid that is present between the plugs can be defined its properties as seen in the image below.

The user can choose from **Seawater**, **Brine** or **other** type of void fluid



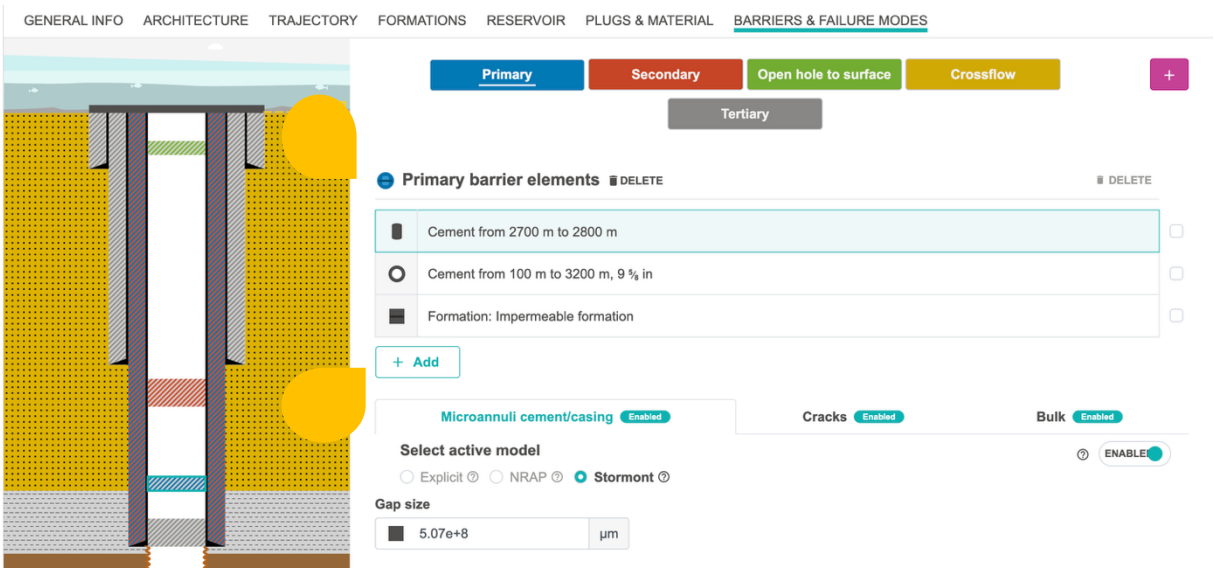
4.7. Barriers (& Failure Modes)

In this last chapter, the barriers and the failure modes are defined by the user. Here, the main part of the whole process takes places, as the user defines different characteristics for each element of each barrier, such as the plug or casing.

Ther are 5 different types of barriers from which to choose:

- **Primary**
- **Secondary**
- **Open hole to surface**
- **Crossflow**
- **Tertiary**

For the **Primary barrier**, the user has the option defining the elements that are in the primary barrier. One can add as many elements as one desire clicking on the button, + Add that is located in the lower left side of the elements of each barrier.



The list of possible barrier elements that the user can add are defined from previous plugs and formations. An example of how that looks can be seen in the image below:

Once the user has decided the number of elements that are defined in each of the barrier, each of the elements has its own characteristics that the user can enable or disable by clicking on 

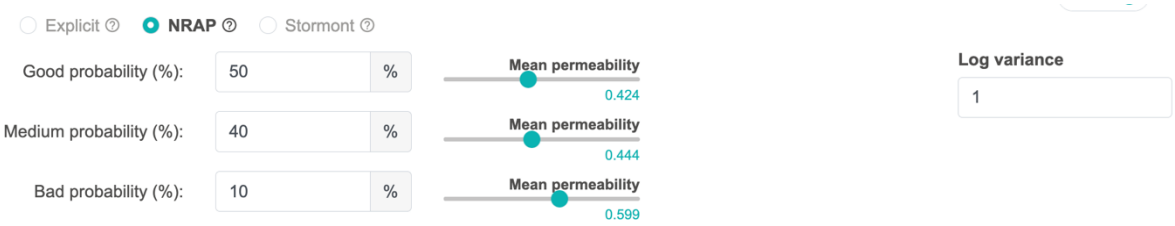
- The **plugs**  have up to three different types of characteristics to define the probable failure. The failure modes that one can expect are:
    - Microannuli cement / casing
    - Cracks
    - Bulk
- The **casing**  has up to four different failures modes to define. Many of them are equal to the plugs case, adding:
    - Microannuli cement / formation
- The **formation**  that is in the barrier element is defined as, has only one failure mode to define:
    - Cracks

4.7.1. Failure Modes

In each of the barrier elements, the user might find the following types of failures modes for each of the barriers. Each of the barrier has its own type of failure mode, which was defined in the previous chapter.

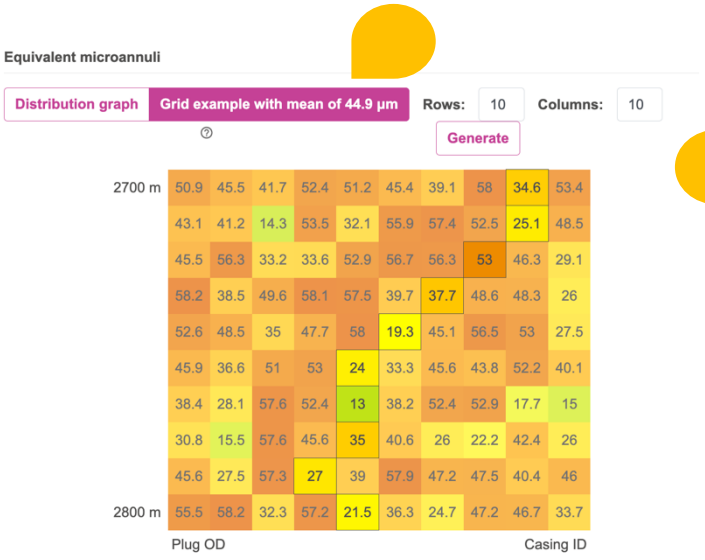
There are four different possible failure modes that can be seen in the following image.

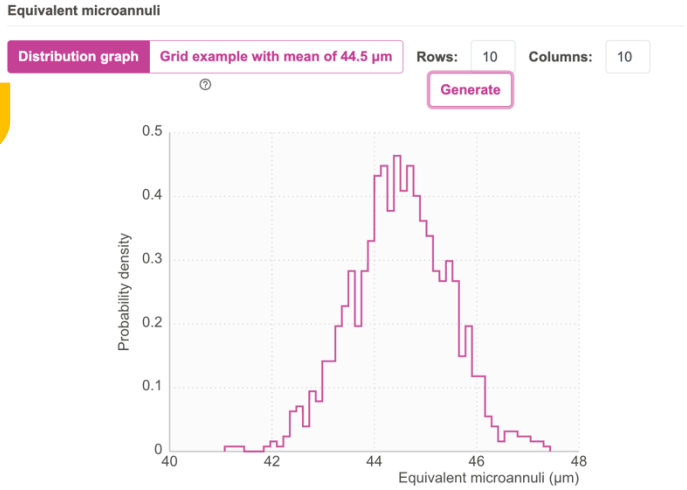
- **MICROANNULI CEMENT/CASING:** Here the user can choose from three different types of models to define the microannuli in the casing.
    - **Explicit:** Here, the user is able to define the gap size as a parameter with its own distribution as explained in chapter 4.4.1. The model assumes the users defined size
    - **NRAP:** The NRAP or National Risk Assessment Partnership framework for geological storage is based on tri-modal probability distribution to generate microannuli sizes. The three probabilities are defined as the following image states:



- **Stormont:** The model, based on the work of Stormont, Fernandez, Taha and Matteo work, where it uses the relation between the effective wellbore permeability stated by the user as a probability distribution and the microannulus hydraulic aperture for generating size.

The user is also given the opportunity to see the equivalent microannuli as a grid example or as a distribution graph in all the three different models. This can be seen in the images below:





In order to create the graph and grid, one has to click on the button **Generate**

- **MICROANNULI CEMENT / FORMATION:** The user is given the same active models as in the microannuli cement for the casing but in this case is only shown when the user is defining the probable failure modes in the casing element.
- **CRACKS:** Cracks are defects that may be present in the well. Here the user can define the possible cracks that can. They can be defined by three different parameters with a defined distribution. They are the following:

- **Aperture**
- **Orientation**
- **Width**

- **BULK:** The bulk is the movement of a fluid or gas through the barrier of the well. To be calculated it is necessary the **permeability** of the material, This parameter has also a probabilistic model.

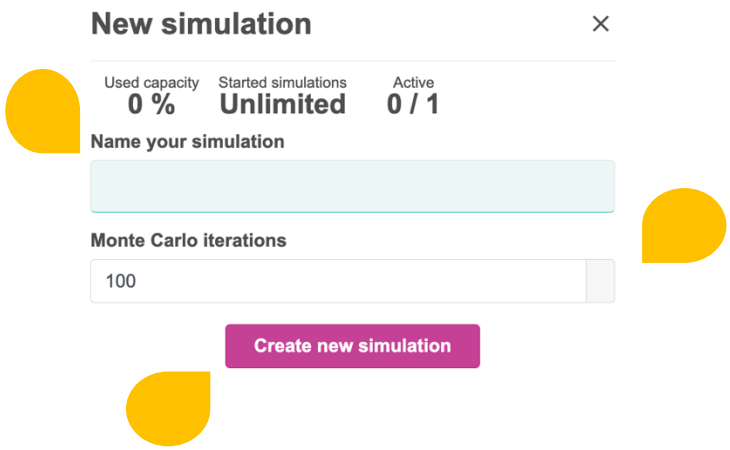
After all of this characterization of each of the possible parameters to define the wells future behavior, the user can initialize the simulation of the P&A Leakage Calculator.

5. Simulation

Once the user has finished making the changes and characterizations that is needed in order to define the well´s shape and formations characteristics, t**he P&A Leakage Calculator can proceed to run the simulation of the leakage.**

To do so, the user clicks on the button + in the left side of the window as seen in the image to the left.

Once the user is able to run the simulation, a pop up will be displayed asking for the **name** of the simulation and the **Monte Carlo Iterations** as the image below will show. The number of iterations that can be written on are a number between 5 and 100.000, however as a standard number, the calculator runs 100 iterations.



The base of the calculation for this program is the Monte Carlo method, which is allows a better probabilistic calculation of the leaks in the well. After the user has entered the necessary inputs, by clicking on **Create new simulation**, the user is forwarded into the **Result Panel** shown in the image below.

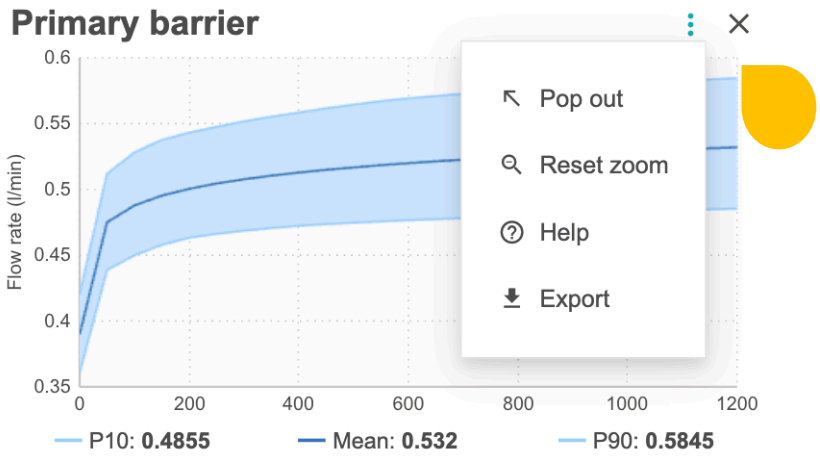
5.1. Result panel

Here, there are many features and graphs that are available for the user to use in order to understand the flow rate of the leakage that is in each of the barriers or elements that one desires.

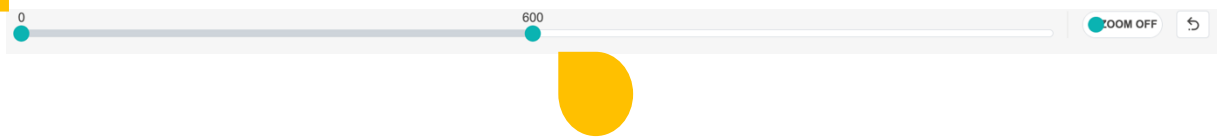
On the left side of the panel, the user is given the freedom to decide which graphs to display onto the panel and how they should be displayed depending on how they want to see it. The following list can be seen in the left side of the panel.

- **Available graphs:**
  - **Barriers** (all of the barriers that the user defined in the previous part)
  - **Barrier elements** (Casings, plugs and impermeable formations)
- **Graph type**
  - **Flow rate**
  - **Mass rate**
- **Measurable location**
  - **At seabed**
  - **At barrier**
- **Failure mode**
  - **All**
  - **Microannuli**
    - **All**
    - **Plug / Casing**
    - **Cement / Casing**
    - **Cement /Formation**
  - **Cracks**
  - **Bulk**

The user is able to move the graphs freely in the panel and decide where to place them and extend or minimize them. Each of the graphs has also a menu in the top right corner. When the user clicks on it, the following menu will appear as the image below.

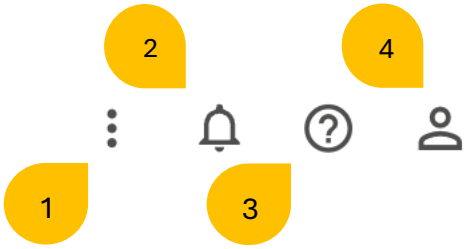


The user is also given the possibility to choose the time that would be shown in the graphs. The calculator is based on a time defined by the user, however, there will be displayed a “time bar” on the top of the panel in order to define the years that the user will be seeing. An example of this bar can be seen in the image below



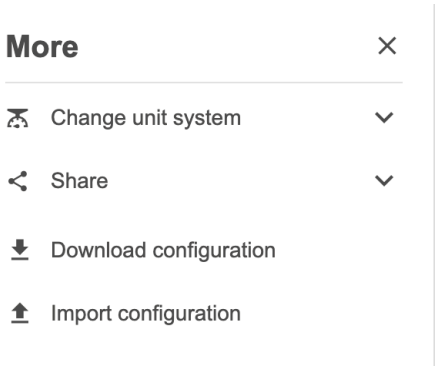
6. Other features

In the right corner of the simulation window a several icons can be found as extra features of for the simulation as seen in the image below. They range from the interface one desires to use to the possibility to export the results of the simulation.



6.1. “More” feature

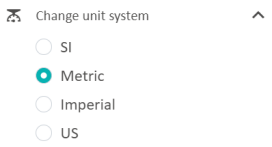
The first icon has more than four different functions that can be mostly used in the usage of the calculator. This features that are shown in the image above, are:



6.1.1. Change unit system:

Four options are available in this feature.

- **SI** or base unit
- **Metric unit**
- **Imperial** (UK)
- **US** or US customary system



6.1.2. Share button:

There are two options in this feature but with the same outcome

- **Copy page link** automatically copies the simulation link into the user´s clipboard
- **Share by email** opens directly the standard email application in order to share the simulation link

Each configuration has a unique configuration ID, and each simulation has a unique simulation ID. These ID's can be found in the URL of the browser as seen below

https://leakage.build.openlab.app/#"
/configurations/c808c415-b547-41e0-ba03-8268f6f656b2
/simulations/9a1d6f64-50eb-4d6d-9ae9-551380a94c12

6.1.3. Download configuration

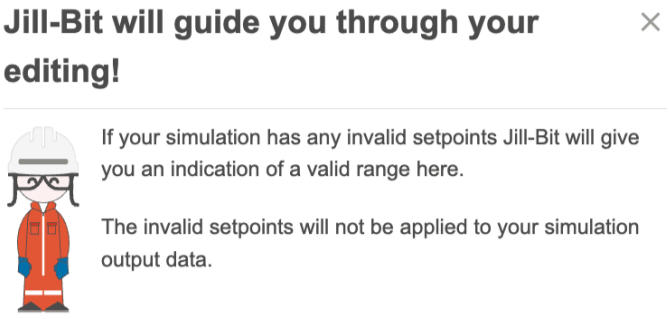
After the calculation of the leakage has been completed, there is the option to download the configuration of the simulation into a **.json** file

6.1.4. Import configuration

Before starting a calculation of the leakage, an existing configuration can be uploaded from a **.json** file

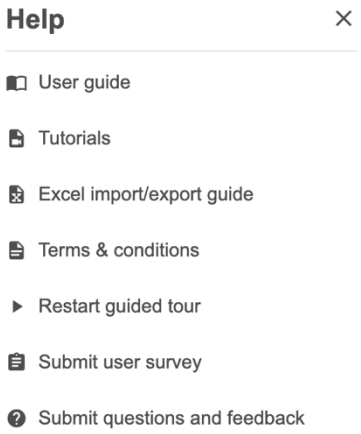
6.2. Error message

In case of having errors in the configuration or the simulation, the icon will show a notification allowing the user to know where the error is made and the solution that is most suitable for the case. In this case a bot called **"Jill-Bit"** will help and guide the user in case of making error or having some incorrect data implemented during the configuration.



6.3. Help icon

The help icon window has seven different subsections



6.3.1. “User Guide” icon

It redirects the user to this user guide in case of having questions or doubts in the process.

6.3.2. Tutorials

The user is redirected into the following website, where one can find many different type of tutorials or guides in order to have a better understanding of the nature of the simulation or the features that it contains.

6.3.3. Excel import / export guide

As the name suggest, the following icon redirects the user into a tutorial that allows to understand in depth the feature of importing and exporting of data via Excel.

6.3.4. Terms and conditions

The “Term and Conditions” notice can be accessed thought this icon.

6.3.5. Restart guide tour

As the name suggest, in case of renewing the guide tour for the simulation, one can do it by clicking the icon.

6.3.6. Submit user survey

In case of having a feedback or a possible review in order to make the platform known its flaws or possible strength one can do it by submitting a user survey.

6.3.7. Submit questions and feedback

As in the previous case, the user can also submit questions or give feedback of the simulation and the configuration of it.

6.4. “User” icon

In this window, one can check the profile, license and also the settings that are used in the simulation and the configuration of the system.