HYPER

HYDRAULIC PUMPS FOR ENERGY RECOVERY

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USER GUIDE

INTRODUCTION

HYPER tool implement an innovative approach for optimal PAT selection in systems with hydraulic and/or electrical regulation,allowing to identify the optimal parameters of a PAT that maximize energy production making the selection of a PAT fast and effective.

A software tool was created to determine the optimal PAT that maximizes energy production for any installation layout. Called HYPER, the app has a Matlab GUI and a Fortran-based engine, based on the model proposed by Fontana et al. [21] and Marini et al. [27], and is designed to determine the optimal parameter values of Q_{Tb} and H_{Tb} using the approach discussed earlier. HYPER v1.0 is freely available on GitHub's hosting website (https://github.com/gustavomarini/HYPER).

The software comprises two main sections, with the first dedicated to loading and preprocessing pattern data, and the second section being where energy domain and optimal solution are calculated. Additionally a specific section in the app makes it possible to convert the optimal PAT characteristics into optimal pump characteristics, thereby making it possible to identify a commercial pump from a manufacturer's catalogue.

The use of HYPER is referred to as: Marini, G.; Di Menna, F; Maio, M.; Fontana, N, (2023). HYPER: computer-assisted optimal PAT selection for microhy-dropower generation and pressure regulation in a WDN

and

Marini, G.; Maio, M.; di Menna, F.; Pugliese, F.; de Paola, F.; Fontana, N. Innovative Approach for Selection of Pump as Turbine in Water Distribution Network. Environmental Sciences Proceedings 2022, 21, doi:10.3390/environsciproc2022021025.

LOADING INPUT DATA

To start the operation to identify the optimal characteristic of PAT the user must provide a pattern of available flow discharge and head drop. This operation is performed in the section ***Load Data.*** In this section the user can provide a pattern data clicking on Load Data button or clicking on import pattern in import section of menu bar (Figure 1)

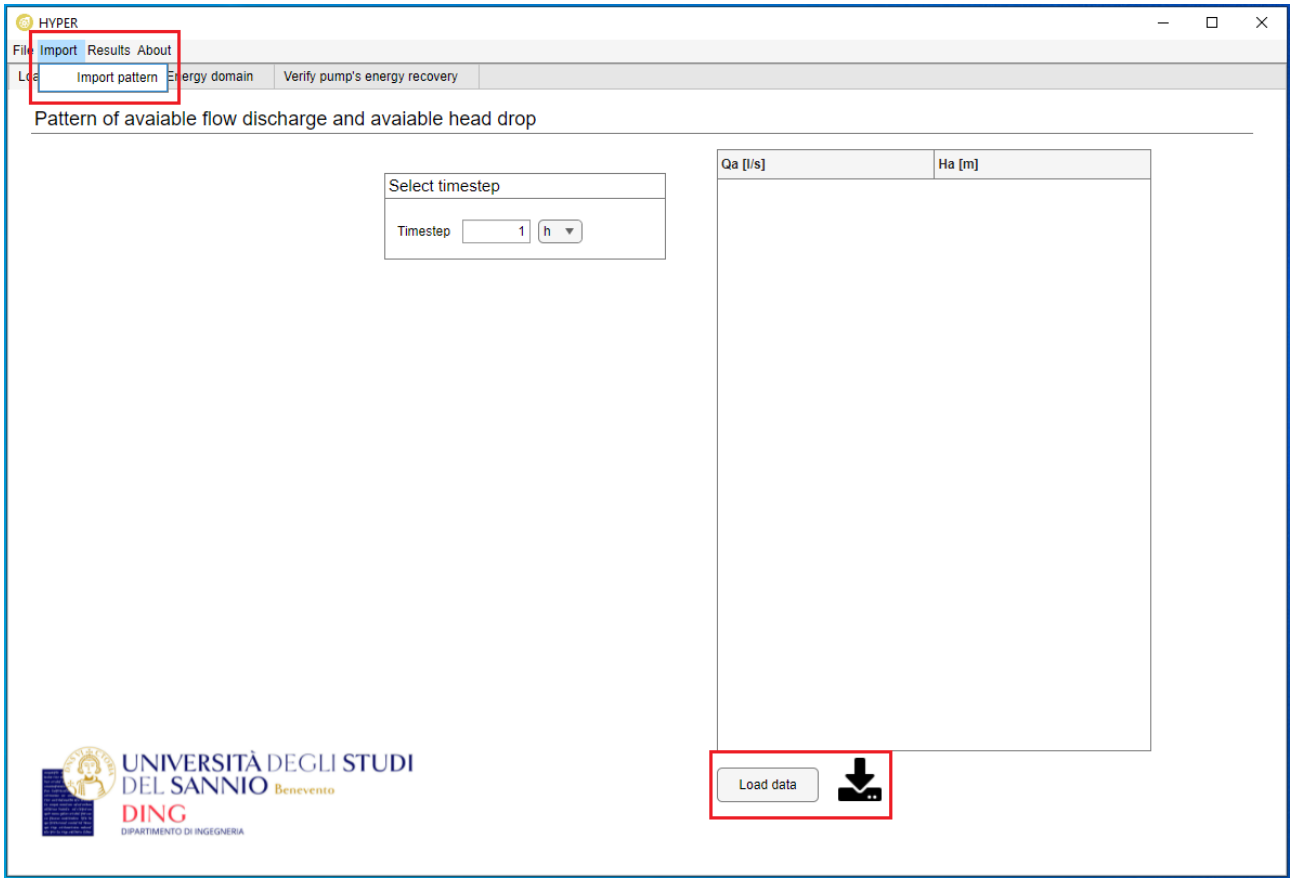

Figure 1 – Click on Load data button to load the data pattern

The data pattern can be provide as a txt file or xslx file, respecting the format provided in the example file (Figure 2-3). Depending on the input pattern the user can set the timestep and select the desired time unit through the corresponding box (Figure 4).

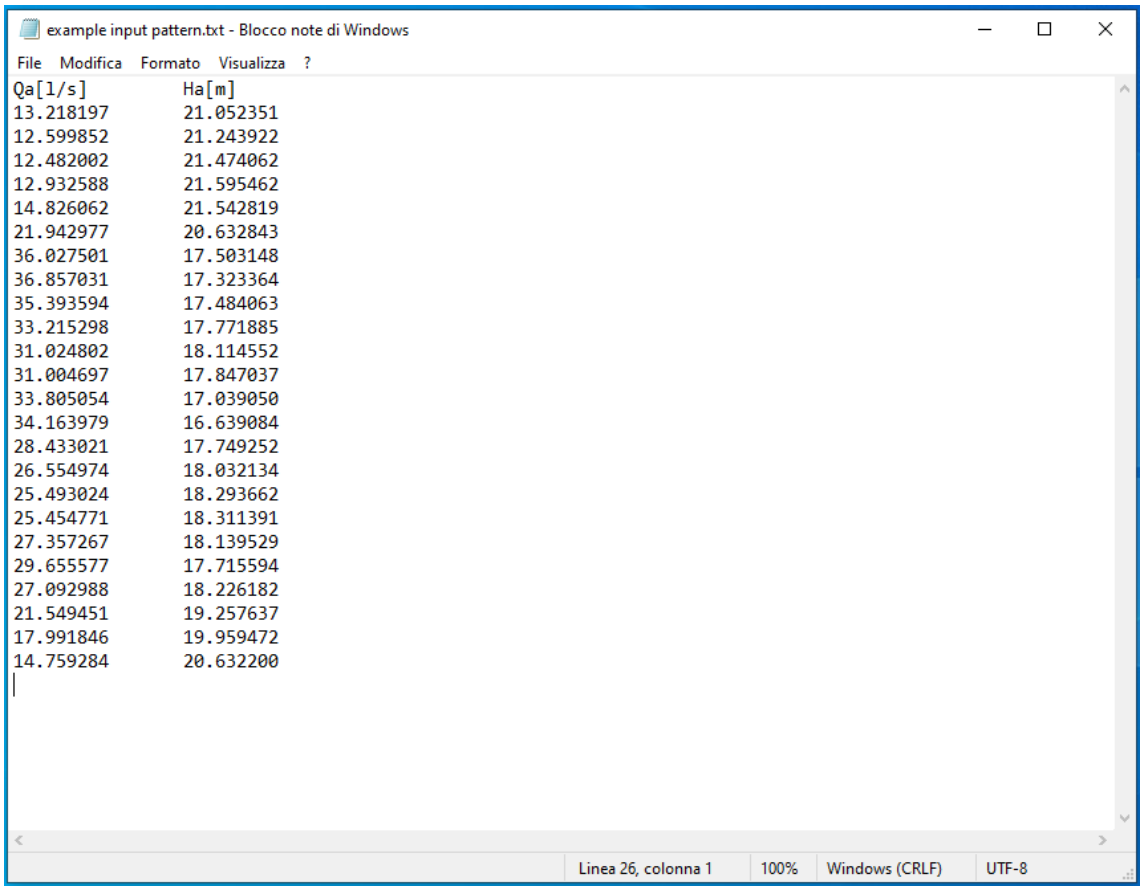

Figure 2 - - Format of txt file to provide for loading data pattern

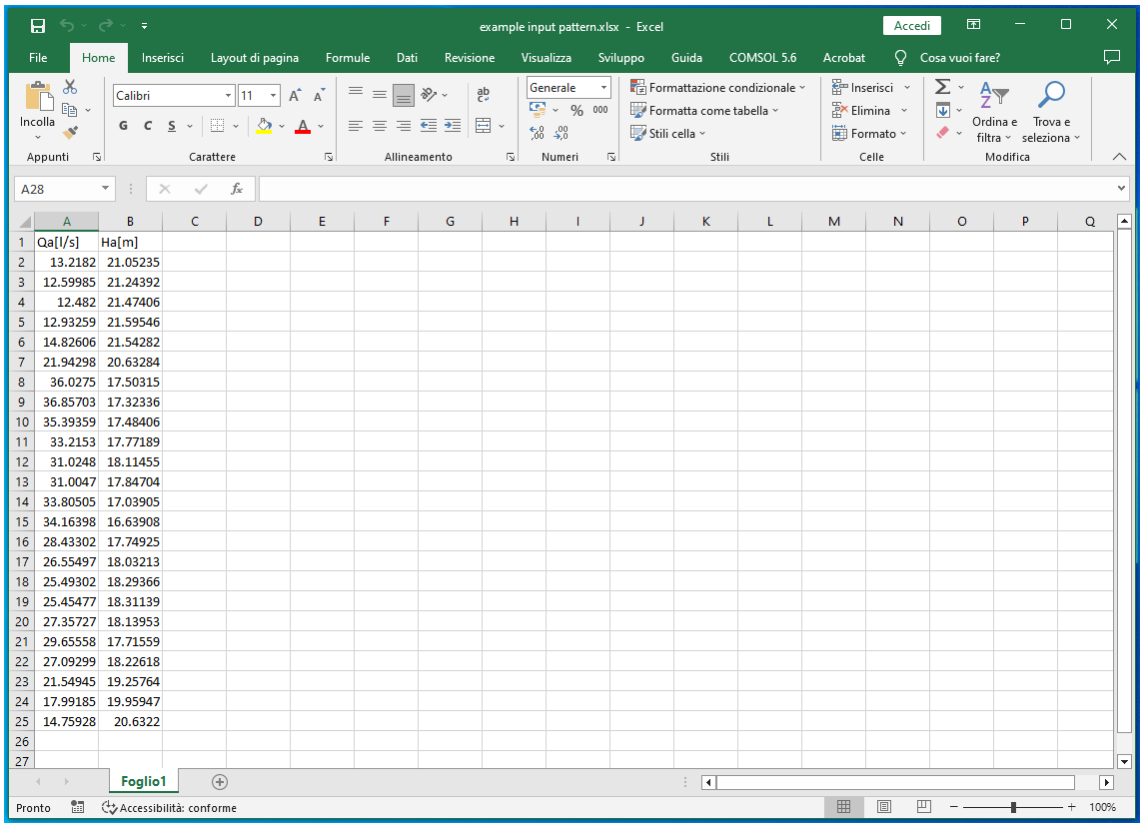

Figure 3 - Format of xslx file to provide for loading data pattern

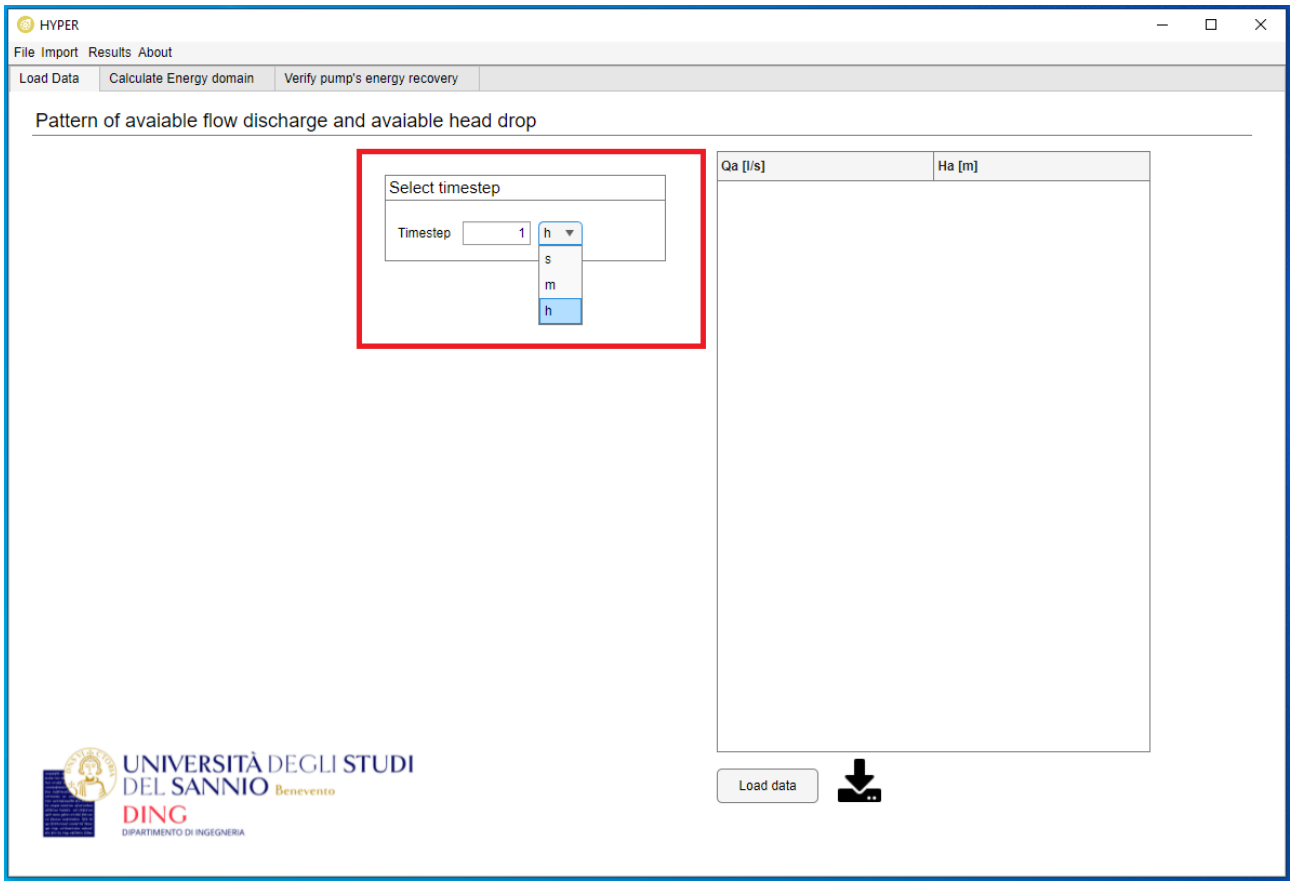

Figure 4 – Select timestep box to set the timestep and corresponding time unit

CALCULATE ENERGY DOMAIN

After uploading the pattern the user can pass to the ***Calculate Energy domain*** section. In this section the software computes the output. The method developed within the software calculates the dimensionless produced energy ($\boldsymbol{e_T}$) at varying $\boldsymbol{Q_{Tb}}$ and $\boldsymbol{H_{Tb}}$ as follows:

$$e_T = \frac{E_T}{E_a \cdot \eta_{Tb}} \tag{1}$$

in which $\boldsymbol{E_a}$ is the daily available energy, $\boldsymbol{E_T}$ is the daily produced energy and $\boldsymbol{\eta_{Tb}}$ is the PAT efficiency at the BEP.

Consequently, the calculation gives a domain showing the relationship between the dimensionless produced energy and the values of $\boldsymbol{Q_{Tb}}$ and $\boldsymbol{H_{Tb}}$, giving the best characteristics individuated for the analyzed case.

In the “set search parameters” box select the PAT layout and set the domain range in terms of $\boldsymbol{Q_{Tb}}$ and $\boldsymbol{H_{Tb}}$ to find the optimal solution and plot the graphic domain. If the user does not set the extremal values of the $\boldsymbol{Q_{Tb}}$ and $\boldsymbol{H_{Tb}}$, the app sets default minimum and maximum values, which are respectively 20% of the average of $\boldsymbol{Q_a}$ (or $\boldsymbol{H_a}$) and 250% of the average of $\boldsymbol{Q_a}$ (or $\boldsymbol{H_a}$) for $\boldsymbol{Q_{Tb}}$ (or $\boldsymbol{H_{Tb}}$). These default values are set so as to find the solution in the zone with maximum energy production. In the corresponding box setting the domain step for brute-force search. After settled the parameters, run the search clicking on Calculate domain button and waiting for the result. The computational time depends on the machine, the domain range, and the domain step: the larger the domain range and denser the domain steps, the greater the computational time (Figure 5).

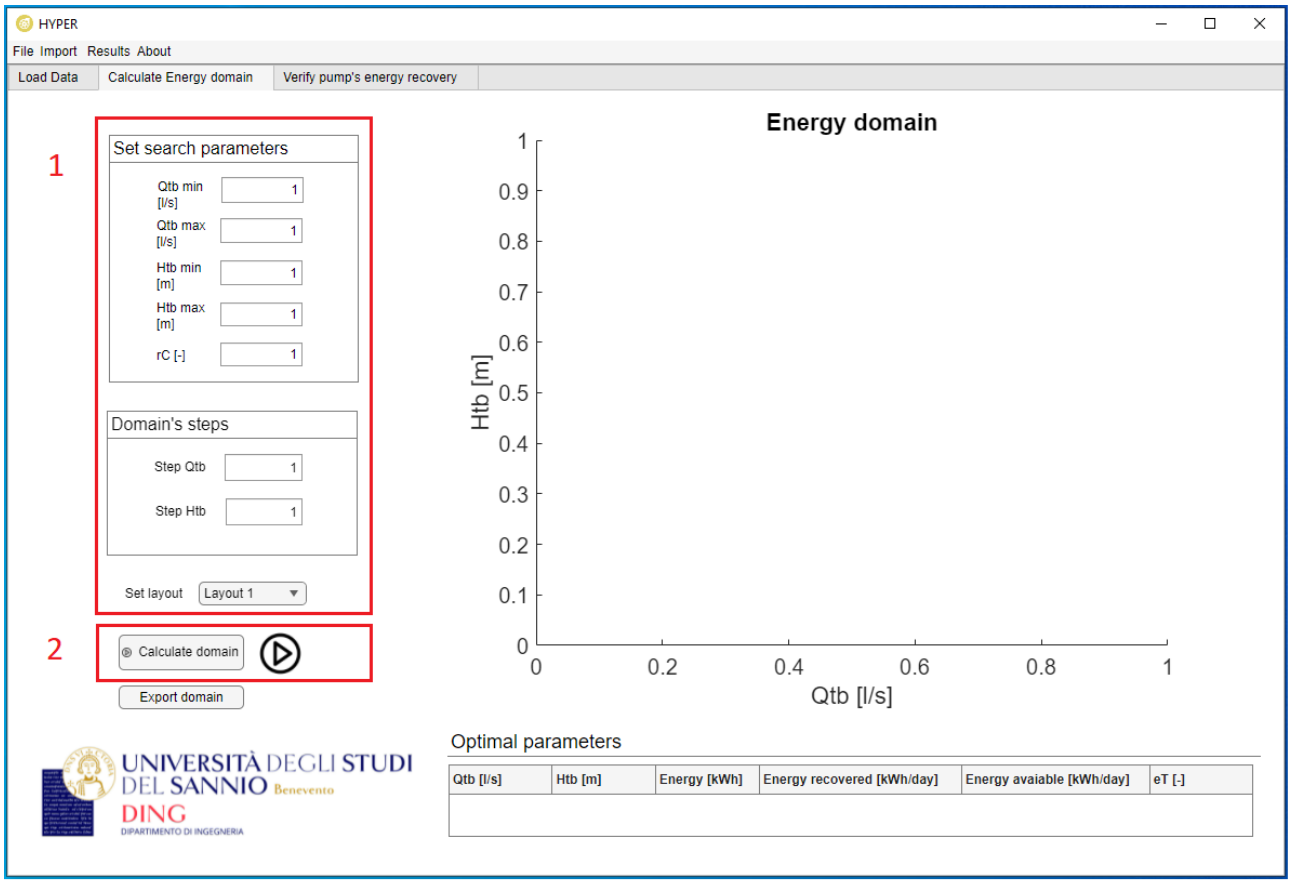

Figure 5 – Calculate Energy domain section

Dimensionless domains were further used to determine the optimal PAT in terms of produced energy and cost, as selected from a manufacturer's list of commercially available pumps.(Figure 6)

The program allows the visualization and export of results, such as the choice of colormap, text size, and image resolution in DPI. Clicking on Export domain button (Figure 7)the user can choose the export option in a “export setting” section and visualize a preview of the export clicking on preview button and save a file clicking on save button (Figure 8).

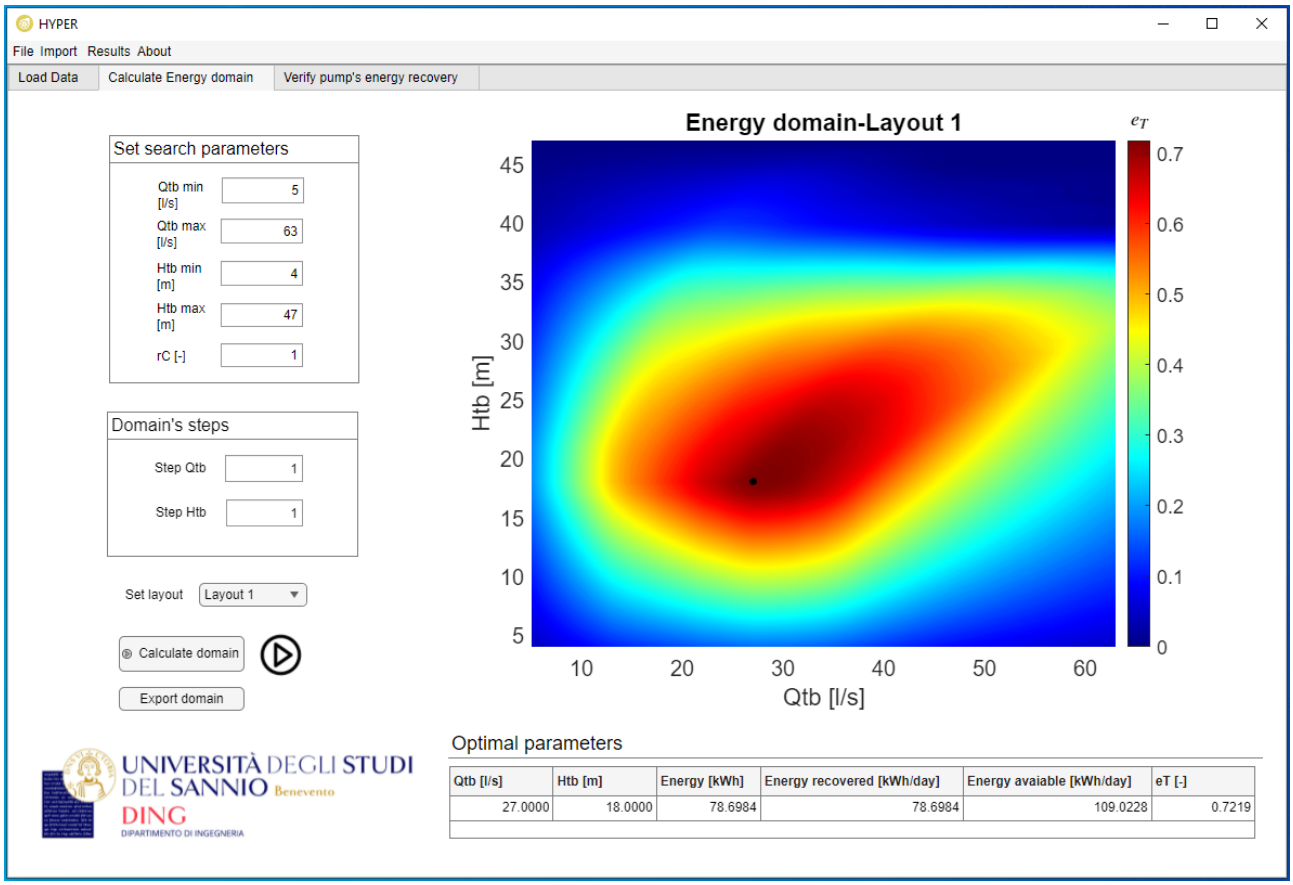

Figure 6 – Dimensionless Energy domain

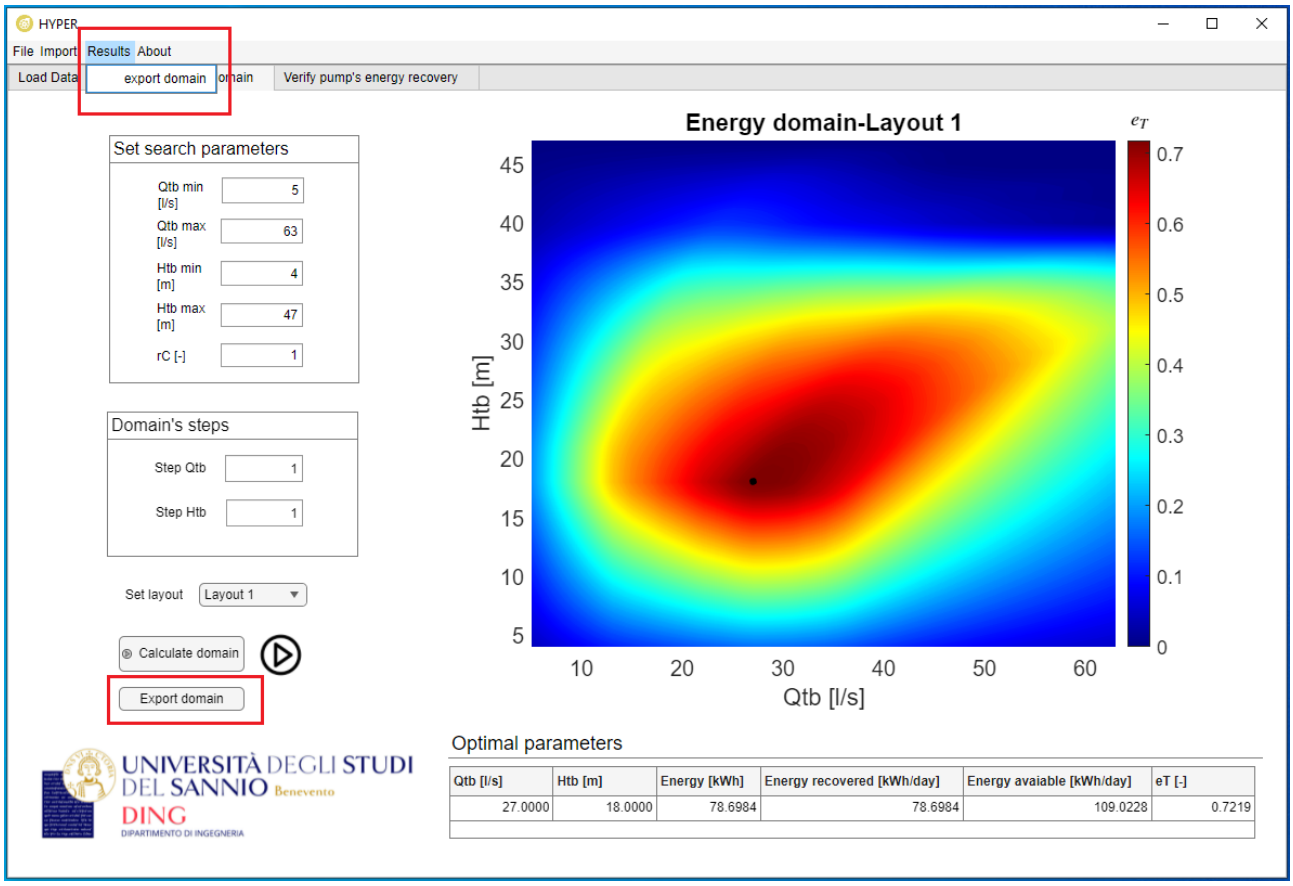

Figure 7 – Export domain buttons

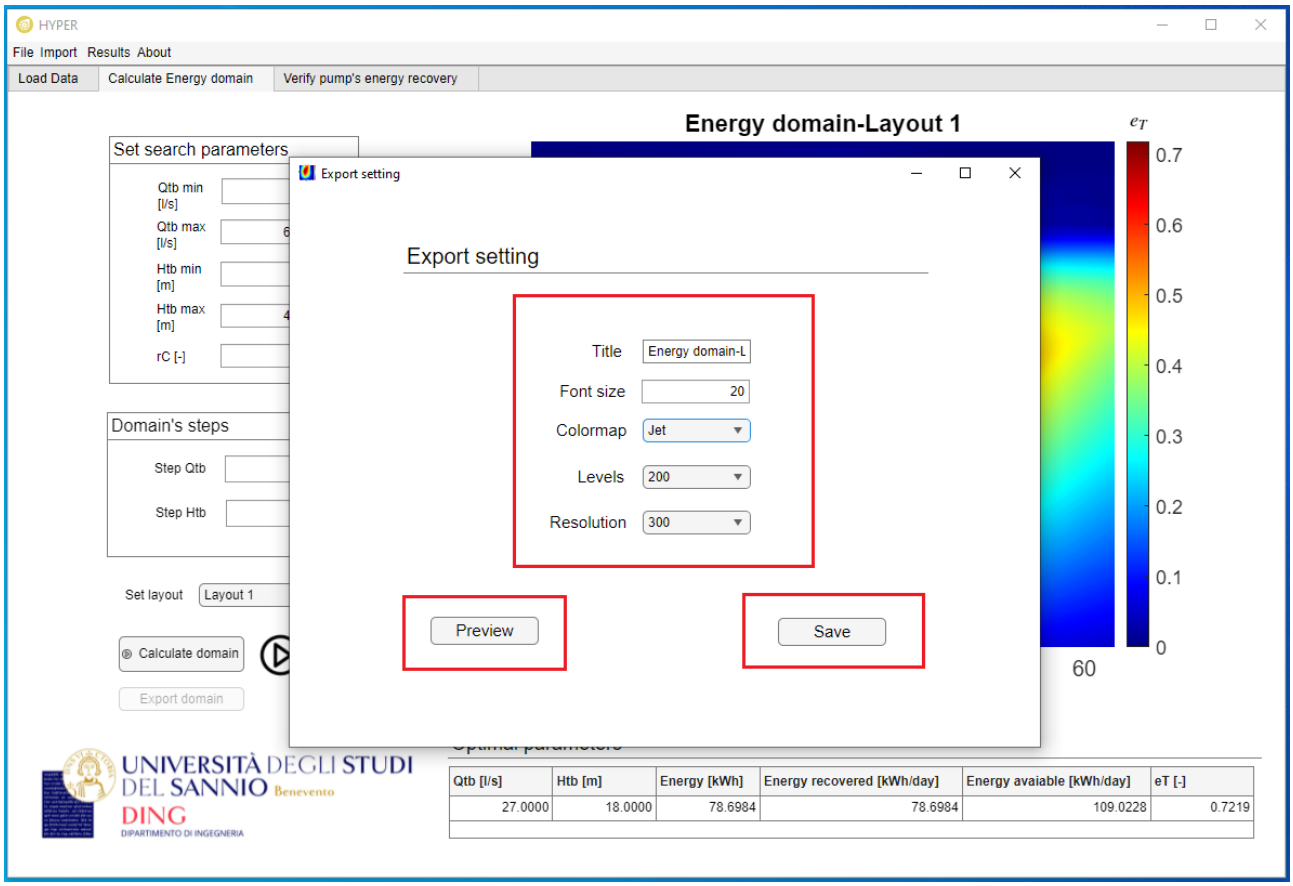

Figure 8 – Export setting

To execute a new analysis, click on file in the menu bar and click on new analysis to erase the fields compiled previously (Figure 9).

If the user want execute a new analysis with the same pattern changing only a few parameters then the user can set directly a new parameters and restart the analysis clicking on the Calculate button

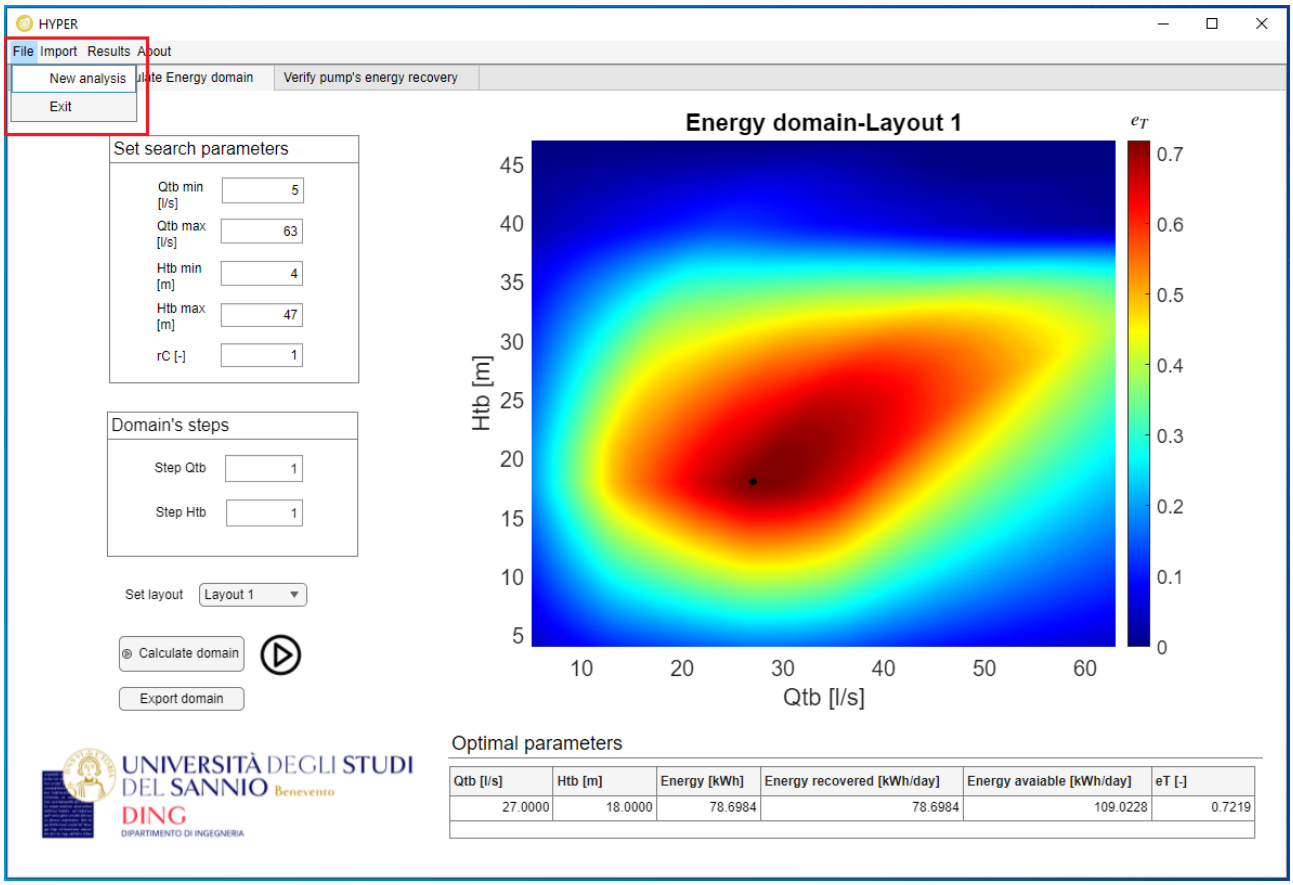

Figure 9 – Execute a new analysis

VERIFY PUMP'S ENERGY RECOVERY

A specific section in the app makes it possible to convert the optimal PAT characteristics into optimal pump characteristics, thereby making it possible to identify a commercial pump from a manufacturer's catalogue.

The user can select a different model conversion to obtain a characteristic in pump mode. The switch button allows the user to set the conversion direction (Figure 10) and consequently a "set parameters" box allows to set the characteristic of the machine (PAT or Pump depending on the conversion direction set).

Click on Covert button to obtain a converted characteristic.

This section allows to obtain an energy production of an inserted pump, for a determined pattern in input, selecting a layout configuration and clicking on the Calculate Energy production button after settled a pump or PAT characteristic and converted it (Figure 11).

This module can also be used only as a converter without providing the pattern data in input.

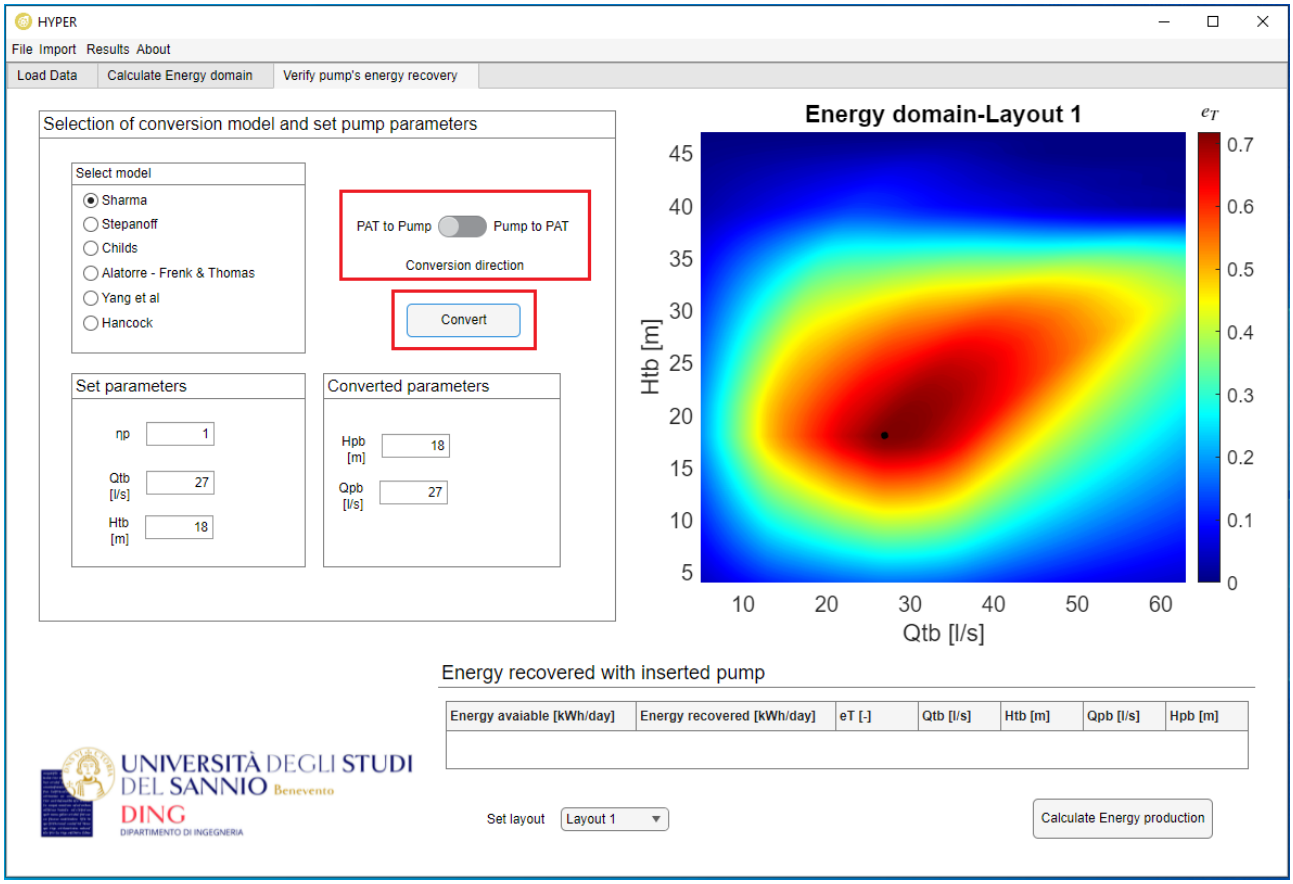

Figure 10 – Switch button to set the conversion direction

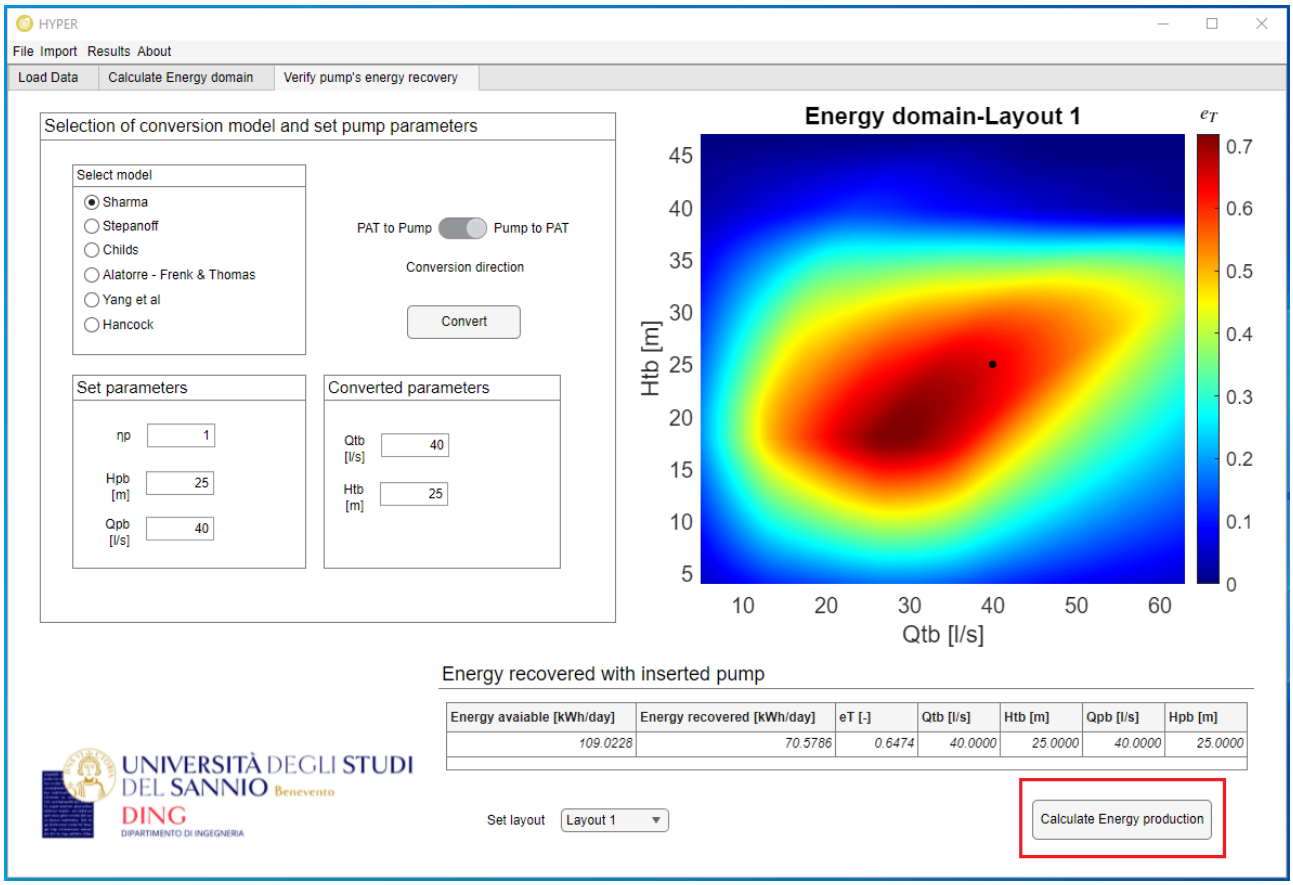

Figure 11 – Energy production for a settled pump