TÉCNICO LISBOA

# Fi²EPI User's Guide

Industrial Heat Process Integration Tool

sgcie
SISTEMA DE GESTÃO DOS CONSUMOS INTENSIVOS DE ENERGIA

ADENE
AGÊNCIA PARA A ENERGIA

GNIP
Grupo Nacional para a Integração de Processos

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# 1. Introduction

Fi$^2$EPI is a web tool that runs in any internet browser as long as a Flash Player plugin is installed. Developed in Adobe Flex/Flash Builder, this tool allows the identification of opportunities in order to improve energy efficiency of industrial processes, both in project stage and retrofit.

The process energy integration methodology adopted in the Fi$^2$EPI's development is based on Pinch Analysis and can be accessed in the Process Integration Brochure (Relvas, 2003) available in a PDF file that can be found at the Process Integration group's website (http://gnip.ist.utl.pt) or together with this manual, in the Fi$^2$EPI tool folder.

This manual was developed to clarify the basics of Fi$^2$EPI's procedures and its uses. For a non-experienced user, Fi$^2$EPI comes along with a set of two examples that can be loaded through the menu. The data for Example 1, for instance, can be simply accessed by opening the Example 1 in the Project tab. To further illustrate Fi$^2$EPI's potential, Example 2 presents a project where a dividing stream problem can be solved in the *MER network* tab (Example 2 data can also be obtained in the menu **Project**/**Open**).

# 2. Fi$^2$EPI's Setup and Requirements

Requirements: Internet browser and Adobe Flash Player plugin must be pre-installed.

To run Fi$^2$EPI for the very first time, one must have access to an internet connection. After this first use, the tool may work offline.

Screen resolution is recommended to be set at least to 1280x800 pixels.

# 3. Welcome screen

Fi$^2$EPI was developed by the Process Integration Group from Centre for Chemical Processes of Instituto Superior Técnico, Lisbon, as a representative member of GNIP. This tool meets the requirements set by ADENE under SGCIE, with control and supervision of DGEG.


**Figure 1 – Fi$^2$EPI's welcome screen**

To start using Fi$^2$EPI, it is necessary to click the **Start** button in order for the tool's main screen to appear.

# 4. Main screen

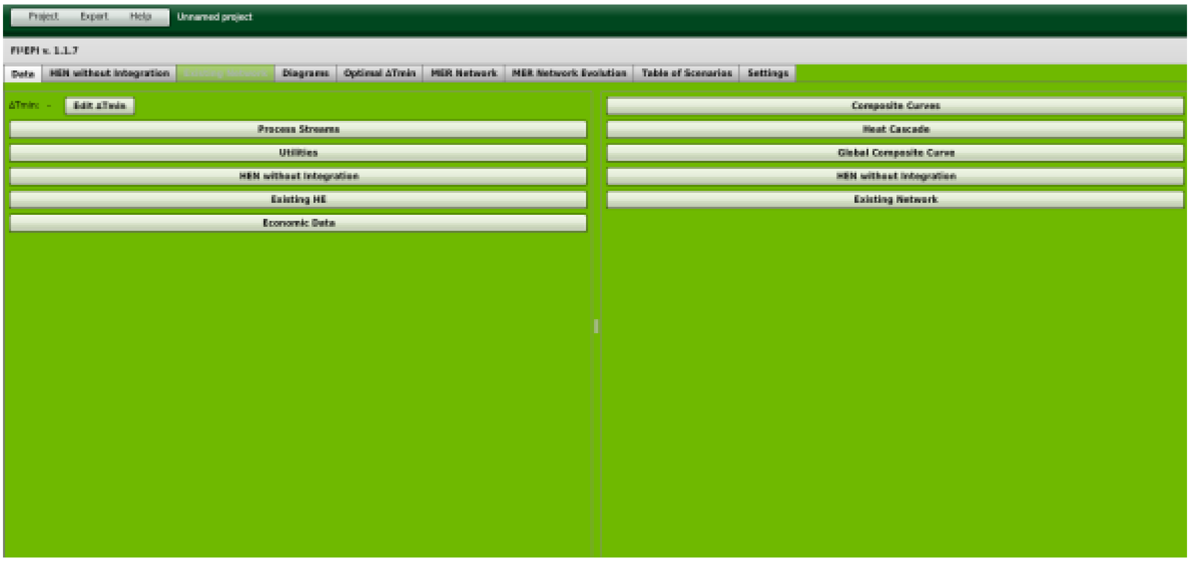



**Figure 2 - Fi²EPI's main screen**

As one can see in Fig. 2, the screen's top bar has three menus (**Project**, **Export** and **Help**) and the project's identification. Note that Fi²EPI doesn't save automatically. By saving your project, a *.fiepi* file is created, being the name given to that file the future name of your project.

There are also eight/nine tabs:

- Data
- HEN without integration
- Existing network *(only if the user specify existing heat exchangers)*
- Diagrams
- Optimal ΔTmin
- MER network
- MER network evolution
- Table of scenarios
- Settings

Each tab consists of a set of windows (that can be opened with a click) grouped into two areas, just like the ones Fig. 2 shows. The window's left side area in each tab allows user interaction with Fi²EPI.

## 4.1 Project Menu

Use this menu to create a new project, to open a previous one or to save one's work in progress project.

### 4.1.1 New submenu

To create a new project, simply select the **New** option in the **Project's** Menu.


**Figure 3 – Creating a new project**

**Note:** This operation will eliminate everything that was previously performed.

### Open submenu

To open a previously saved project, choose **Open** in the **Project's** Menu.

The project name will appear right next to the Menu bar.


**Figure 4 – Opening a previously saved project**

### Save submenu

Fi²EPI does not automatically save any changes to the original file. Hence, it is necessary to save the project if intended.

To do so, select **Save** in the **Project's** Menu. There, one can name a project and choose a folder where to save it.


**Figure 5 – Saving a project**

Once save is performed, the name of the project shall appear right next to the Help tab in the Menu's bar.

**Note:** The project name will be *Unnamed project*, as long as the project is not saved.

## *Export Menu*

This menu allows exporting tables, graphs and networks.

### Tables submenu

FI²EPI allows exporting several projects' tables to an image file extension or to a CSV (Comma Separated Values) file extension. To do so, select **Export** in the Menu followed by **Tables** and choose the table to be exported.


**Figure 6 – Table exportation menu**

**Note:** CSV files are generally used in spreadsheets. To correctly import a CSV file from Fi$^2$EPI, the source of the file as being Western (Windows Latin 1) should be preferably chosen in the final application. If one's allowed to choose between delimited file or with fixed width, choose delimited file, and use semicolon ";"as delimiter. The decimal separator should be a dot ".".

#### Graphs submenu

The graphs created with this tool can be exported to an image file with width and height specified by the user, thus the file size is defined in pixels. It is also possible to export to a CSV (Comma Separated Values) file, *see note in Export Tables*. To export a graph, select **Graphs** in the **Export** Menu and select the graph to be exported.


**Figure 7 – Graph exportation menu**

#### Networks submenu

The heat exchangers networks (HEN) of the project can also be exported to an image file with width specified by the user (being limited by the minimum width of the network). To do so, select **Networks** in the Menu **Export** and choose the network to be exported.


**Figure 8 – Networks exportation menu**

### *Help menu*

This menu allows access to this manual, as well as to general information about the version of Fi$^2$EPI in use.

#### Fi$^2$EPI's Manual submenu

Select **Fi$^2$EPI's Manual** in the **Help** Menu to access this manual, through Fi$^2$EPI tool.


**Figure 9 – How to get FI$^2$EPI's user guide**

#### Process Integration Brochure submenu

To access the Process Integration Brochure through FI$^2$EPI, one should select **Process Integration Brochure** in the **Help** Menu.


**Figure 10 – How to get the Process Integration Brochure (PT version only)**

### About Fi²EPI submenu

To know the features about Fi²EPI, select **About FI²EPI** in the **Help** Menu.


**Figure 11 – How to be sure about your FI²EPI version**

## *5. Data Tab*

Data input is made in the **Data** tab, through the windows found on the left area: *Process Streams*, *Utilities*, *Existing HE* and *Economic Data*.

**Figure 12 – The Data tab: divided into two areas, the left one is used for inputs while the other one is where results can be confirmed**

**Note:** If *ΔTmin* is not introduced at the beginning, adding *Process Streams* and *Utilities*, shall not generate the *Heat Cascade*, the *Global Composite Curve* and the *HEN without Integration*.

### Process Streams window

Click the *plus* (**+**) button that appears in the window *Process Streams* to provide Fi²EPI process streams' data.

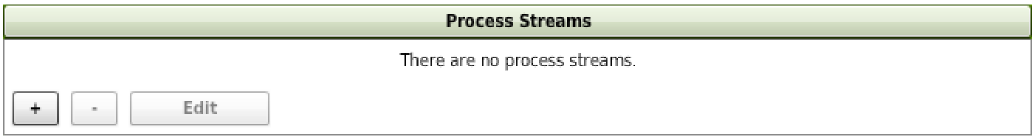



**Figure 13 – Process streams window (stream adding)**

In Fig. 1, one can find the data requirements for the process streams generation. The data input is quite easy, since $Fi^2EPI$ green shades the field if the data input is compatible with the respective field. One is able to give as inputs: a description, the initial and final temperatures (Ti and Tf, respectively), a heat transfer coefficient (h), a flow (M) and an average heat capacity (Cp) or a MCp, selecting one of the available units.

The heat transfer coefficient (h) is set at 0.5 $kW.m^{-2}.^{o}C^{-1}$ and it is a default value that can be changed if the user has more accurate data on the process streams fluids. The heat per unit of time (Q) is automatically computed and displayed at the bottom of the *Add Process Stream* tab, right after a correct data input is made, as previously mentioned.

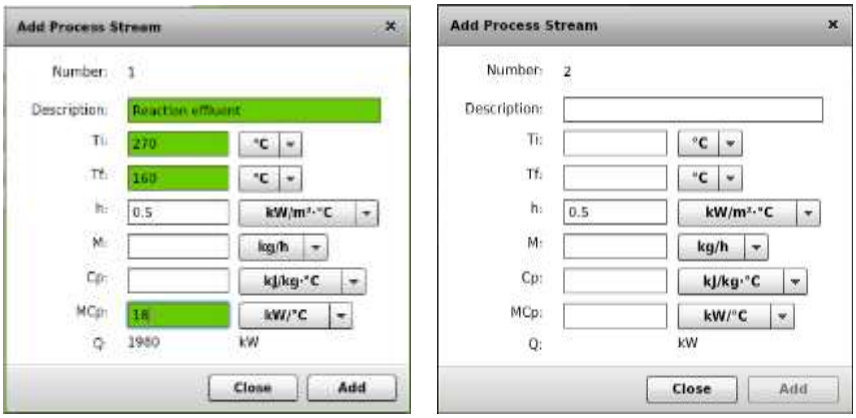
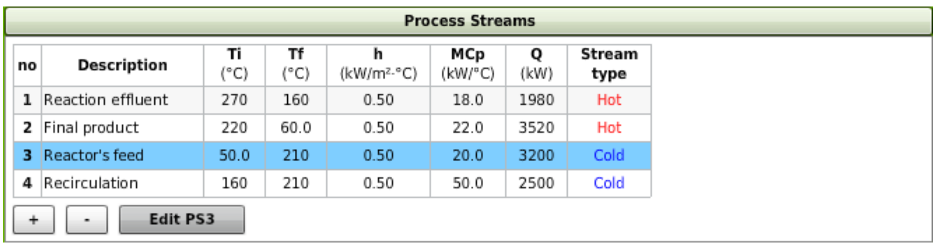



**Figure 14 – Process streams editing menu**

To continue adding process streams, click on the **Add** button once data input for one stream is completed. The user can add as many streams as wished just by filling the field gaps, as shown in Fig. 14, and pressing the **Add** button. This procedure adds process streams to the table in the *Process Streams* window. When the stream definition process is completed, click on the **Close** button.

Select a stream in the table and click on the **Edit** button to edit a stream (Fig. 15), change what is necessary and click on the **OK** button.

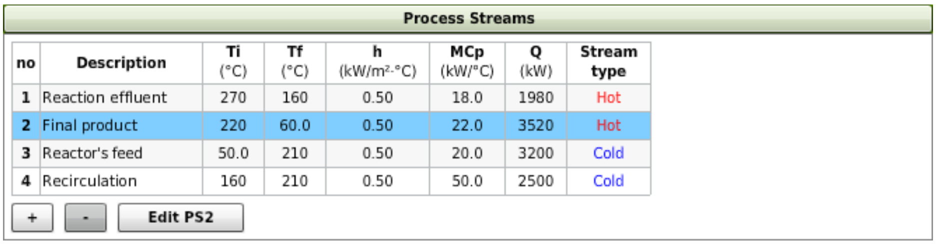

Process Streams

| no | Description | Ti (°C) | Tf (°C) | h (kW/m²·°C) | MCp (kW/°C) | Q (kW) | Stream type |
|---|---|---|---|---|---|---|---|
| 1 | Reaction effluent | 270 | 160 | 0.50 | 18.0 | 1980 | Hot |
| 2 | Final product | 220 | 60.0 | 0.50 | 22.0 | 3520 | Hot |
| 3 | Reactor's feed | 50.0 | 210 | 0.50 | 20.0 | 3200 | Cold |
| 4 | Recirculation | 160 | 210 | 0.50 | 50.0 | 2500 | Cold |



**Figure 15 - Process streams window (stream editing)**

To eliminate a stream, select the stream in the table and click on the **–** (*minus*) button.



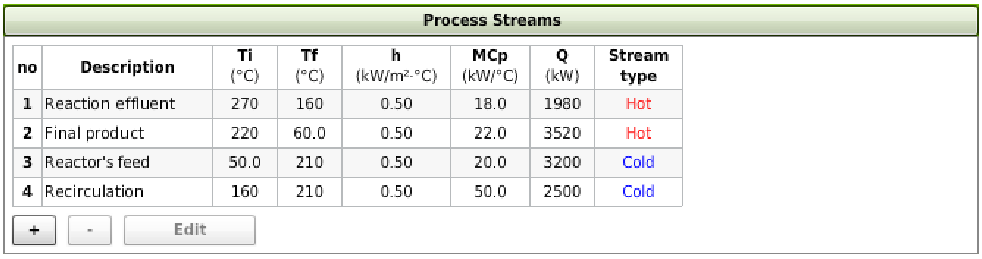
Process Streams

| no | Description | Ti (°C) | Tf (°C) | h (kW/m²·°C) | MCp (kW/°C) | Q (kW) | Stream type |
|---|---|---|---|---|---|---|---|
| 1 | Reaction effluent | 270 | 160 | 0.50 | 18.0 | 1980 | Hot |
| 2 | Final product | 220 | 60.0 | 0.50 | 22.0 | 3520 | Hot |
| 3 | Reactor's feed | 50.0 | 210 | 0.50 | 20.0 | 3200 | Cold |
| 4 | Recirculation | 160 | 210 | 0.50 | 50.0 | 2500 | Cold |



**Figure 16 - Process streams window (stream removal)**

The final table of the Process Streams sums up the key information about each stream: description, Ti, Tf, h, MCp, heat duty and stream type (cold or hot).



Process Streams

| no | Description | Ti (°C) | Tf (°C) | h (kW/m²·°C) | MCp (kW/°C) | Q (kW) | Stream type |
|---|---|---|---|---|---|---|---|
| 1 | Reaction effluent | 270 | 160 | 0.50 | 18.0 | 1980 | Hot |
| 2 | Final product | 220 | 60.0 | 0.50 | 22.0 | 3520 | Hot |
| 3 | Reactor's feed | 50.0 | 210 | 0.50 | 20.0 | 3200 | Cold |
| 4 | Recirculation | 160 | 210 | 0.50 | 50.0 | 2500 | Cold |



**Figure 17 - Process streams window (completely filled)**

### Utilities window

To add utilities, click on the **+** button in the *Utilities* window and, when the editing menu unlocks, choose the Class of Utility, fill in the description as well as other required elements.

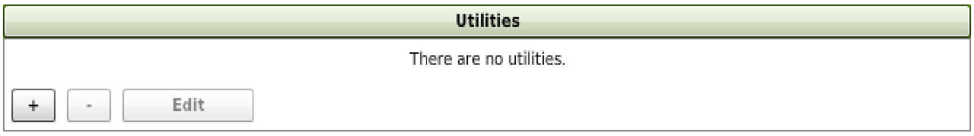



**Figure 18 – Utilities window (utility adding)**

**Note:** Price and heat transfer coefficient have default values, along with the Cp of refrigeration water that should be changed in case more accurate values exist.

There are five types of utilities available: Saturated Steam, Thermal Fluid, Condensate, Refrigeration Water and Refrigeration Fluid.

The utility is only added to the table after clicking on the **Add** button, once the respective data input is completed.

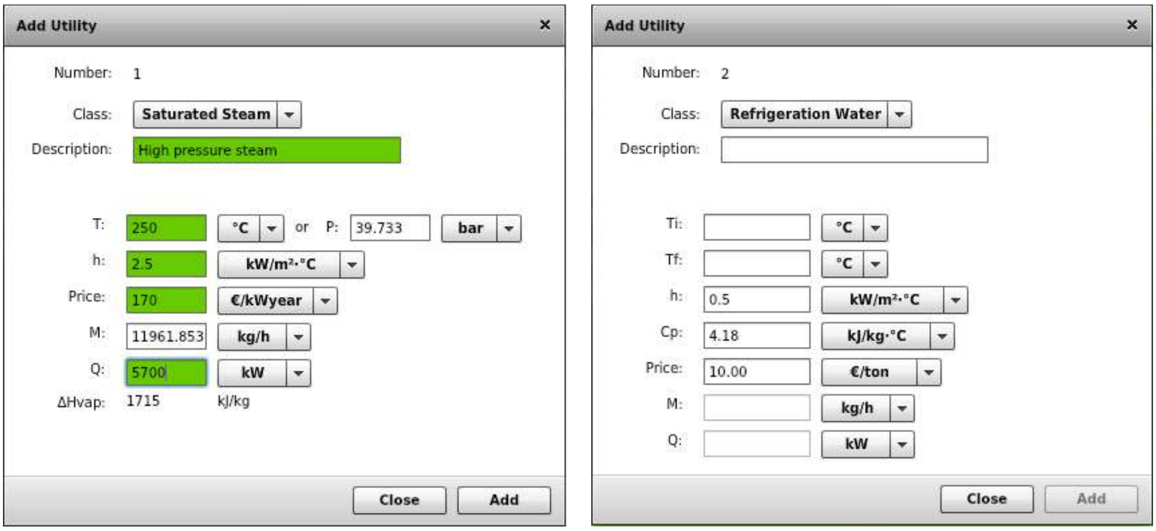



**Figure 19 - Utilities editing menu**

In order to characterize a saturated steam, it is only necessary to provide the saturation temperature or the saturation pressure, as the other non-specified variable is computed according to thermodynamic tables.

In the *Utilities* table, the condensed information of each utility is listed: type of utility, initial and final temperatures, h, Q and price.

**Utilities**

| no | Description | Existing | Ti (°C) | Tf (°C) | h (kW/m²·°C) | Q (kW) | Price | Use in MER Network |
|---|---|---|---|---|---|---|---|---|
| 1 | High pressure steam | NO | 250 | 250 | 2.50 | 5700 | 170.00 €/kWyear | ☑ |
| 2 | Cooling water | NO | 15.0 | 20.0 | 1.00 | 5500 | 3.00 €/kWyear | ☑ |

+ | - | Edit

**Figure 20 - Utilities window (completely filled)**

There are also two box-ticking columns of marking boxes: **Existing** and **Use in MER Network**. The first column provides information on whether or not the utility exists in the *Existing Network*. The second column is used to choose the utilities that should be used in the MER network creation.

The Q value, which corresponds to the hot/cold utility, only appears when there are cold/hot process streams. If the **Existing** column is not marked, the Q value that appears in the shortened table will be the respective maximum thermal duty required to meet all the needs of the cold and hot process streams without integration.

If some process integration attempt was already established in the process, the **Existing** column should be marked and the Q value that appears in the shortened table refers to the remaining utility requirements in order to fulfil all the cold and hot streams yet to be integrated. This value rises as coolers and/or heaters are being added to the *Existing HE* window. To abridge, as long as the existing network is not complete, this value will be zero.

### Existing HE window

In this window, heat exchangers that already exist in the network will be added.

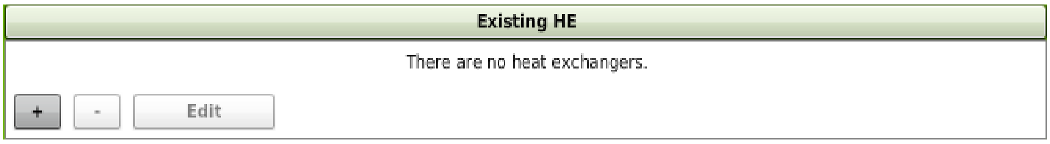



**Figure 21 – Existing HE table**

In order to add heat exchangers, click in the **+** button (Fig. 21) and then choose the process and/or utility streams accessible in each exchanger (Fig. 22), as well as the initial and final temperatures of each stream/utility. Finally, click on **Add**.

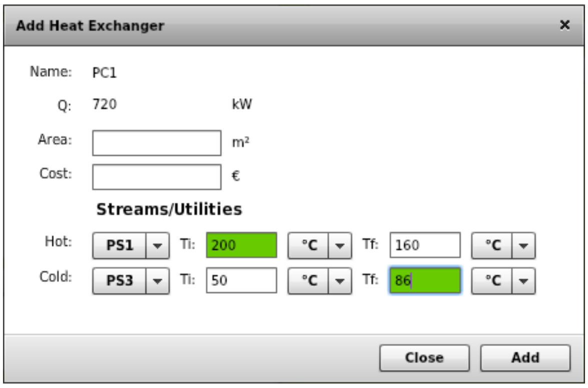



**Figure 22 – *Add Heat Exchanger* editing menu**

If the user has the real exchanger area value, as well as its cost, it is possible to add them.

If real values aren't provided, the area of the exchangers will be computed based on the project equation for shell and tubes heat exchangers in pure counter-flow and their cost shall be determined using the cost laws presented in the *Economic Data* window.

When existing exchangers are introduced, the corresponding network diagram shall progressively be drawn and it will appear in the *Existing Network*, placed at the right of the working area.

Existing HE

| Streams/ Utilities | HE1 Q=720 kW | | HE2 Q=880 kW | | HE3 Q=1260 kW | | HE4 Q=2640 kW | | HE5 Q=2480 kW | | HE6 Q=1620 kW | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) |
| PS1 | 200 | 160 | | | 270 | 200 | | | | | | |
| PS2 | | | 220 | 180 | | | 180 | 60.0 | | | | |
| PS3 | 50.0 | 86.0 | | | | | | | 86.0 | 210 | | |
| PS4 | | | 160 | 178 | | | | | | | 178 | 210 |
| UT1 | | | | | | | | | 250 | 250 | 250 | 250 |
| UT2 | | | | | 15.0 | 20.0 | 15.0 | 20.0 | | | | |

+ - Edit

**Figure 23 – Existing HE network table**

In the aforementioned *Existing Network* window, the streams will appear dashed until their requirements of thermal duty are completely fulfilled whether by commuting with other streams and/or utility.

**Note:** The utilities to be used in the *Existing Network are necessarily* marked as "Existing" in the *Utilities* table, in order to provide later access to them to complete the network.

### Economic Data window

In the *Economic Data* window, the parameters' values of the cost laws for heat exchangers can be placed in, along with other economic parameters that will be used to determine the equivalent annual cost.

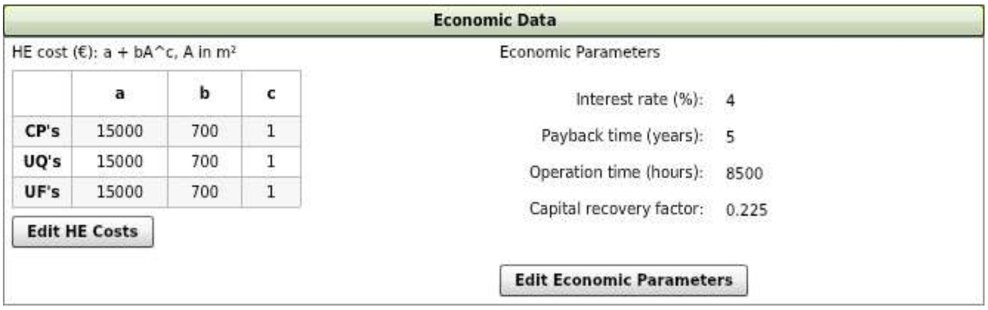



**Figure 24 – Economic Data window**

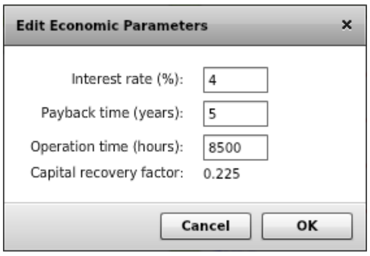



**Figure 25 – Economic Parameters editing menu**

The cost laws and the economic parameters have default values which can be changed by clicking on the **Edit HE Costs** or **Edit Economic Parameters** buttons (Fig. 24).

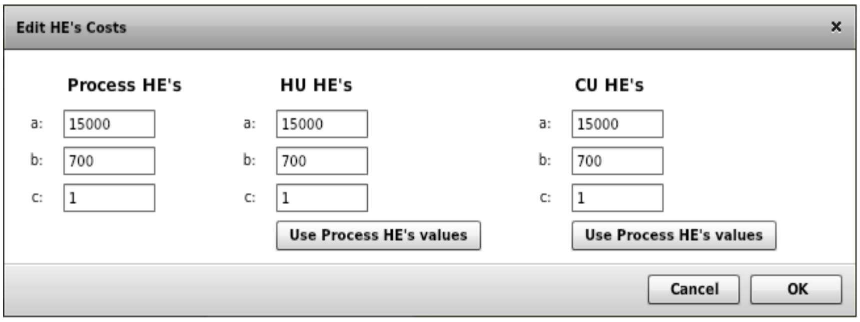



**Figure 26 – HE cost laws parameters editing menu**

It is possible to specify different parameters for the cost laws of process streams' heat exchangers, heaters or coolers.

**Note:** When adding new values in the cost laws of process stream heat exchangers, one can choose to use the same cost law for heaters (HU HE's) or coolers (CU HE's) (which are HE's that resort to utilities and not only process streams) simply by clicking on the **Use Process HE's values** button.

### ΔTmin window

The ΔTmin can be changed in FI²EPI left top corner, by clicking on the **Edit ΔTmin** button.

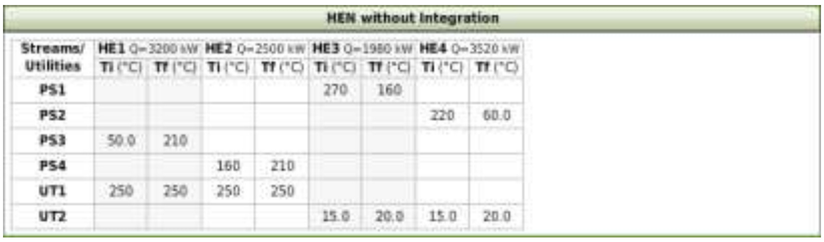

**Figure 27 – ΔTmin editing menu**

The ΔTmin is changed in all tabs automatically and the calculations using this variable are updated and computed accordingly every time their value is reformed.

**Note:** To build *HEN without integration*, *Global Composite Curve* and *Heat Cascade* it is necessary to define a ΔTmin value.

### HEN without Integration window

The table with the heat exchangers from the network without integration (Fig. 28) is built assuming that all streams are satisfied at the utilities expense, without any energy integration attempt, and concerning the ΔTmin previously established.



HEN without Integration

| Streams/ Utilities | HE1 Q=3200 kW | | HE2 Q=2500 kW | | HE3 Q=1980 kW | | HE4 Q=3520 kW | |
|---|---|---|---|---|---|---|---|---|
| | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) |
| PS1 | | | | | 270 | 160 | | |
| PS2 | | | | | | | 220 | 60.0 |
| PS3 | 50.0 | 210 | | | | | | |
| PS4 | | | 160 | 210 | | | | |
| UT1 | 250 | 250 | 250 | 250 | | | | |
| UT2 | | | | | 15.0 | 20.0 | 15.0 | 20.0 |

**Figure 28 – HEN without integration concise table**

The network without integration is drawn on the right side of the working area, at the *HEN without Integration* window.

Streams will appear dashed if the provided utilities do not match the ΔTmin.

**Note:** This window does not have the editing option and it's only built after ΔTmin value input.

On the in right area of the *Data* tab, one can access the following windows: *Composite Curves*, *Heat Cascade*, *Global Composite Curve*, *HEN without Integration* and *Existing Network*.

### Composite Curves window

Composite curves are displayed in the *Composite Curves* window, and the curves will be constructed simultaneously with stream definition, even if no ΔTmin value is established.

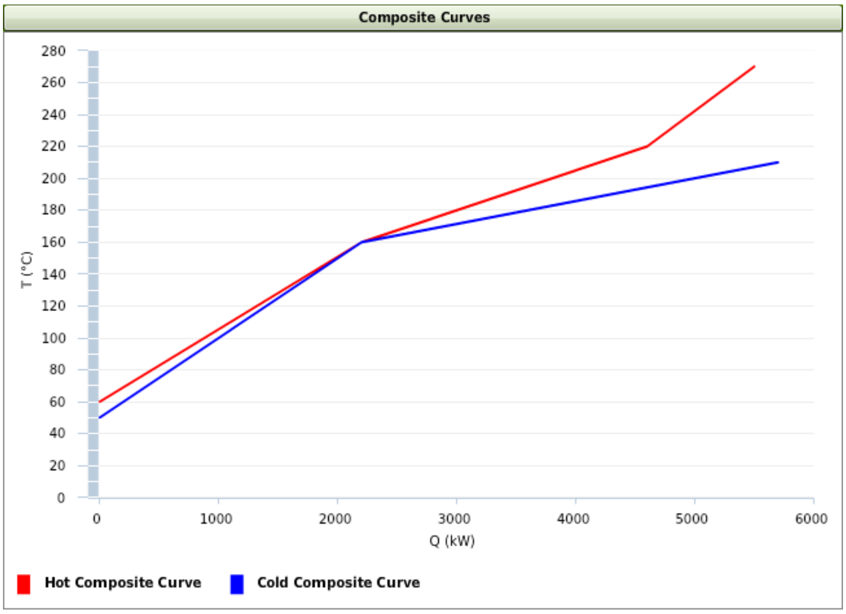



**Figure 29 – Composite Curves with no ΔTmin value previously established**

The pinch point location is displayed in the figure (Fig. 30) when a *ΔTmin* value is added, along with the minimum thermal duty values required in terms of cold and hot utility.

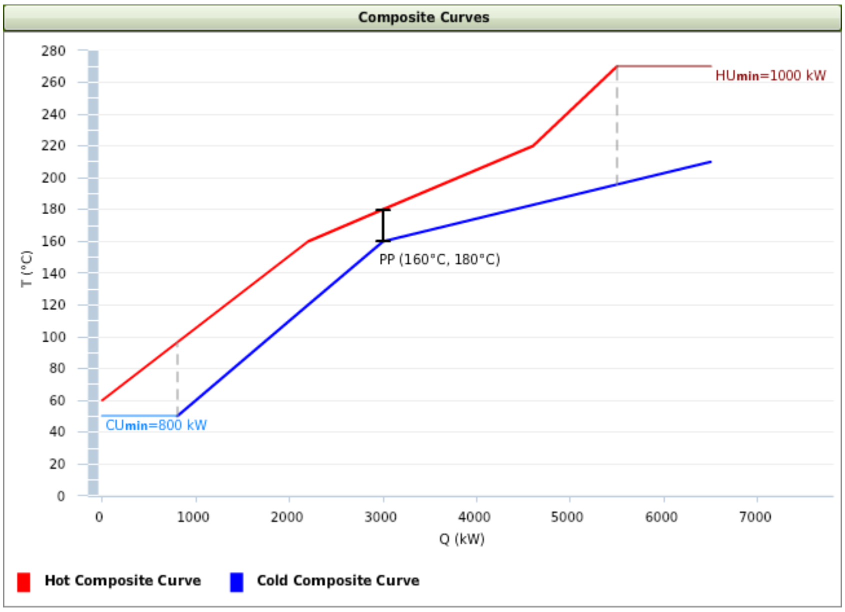



**Figure 30 – Composite Curves with pinch point representation**

### Heat Cascade window

In the Heat Cascade window, the heat cascade is drawn at the same time *Process Streams* are added and the results are identical to those obtained using the graphical pinch approach (Fig. 31) for the considered *ΔTmin* value.

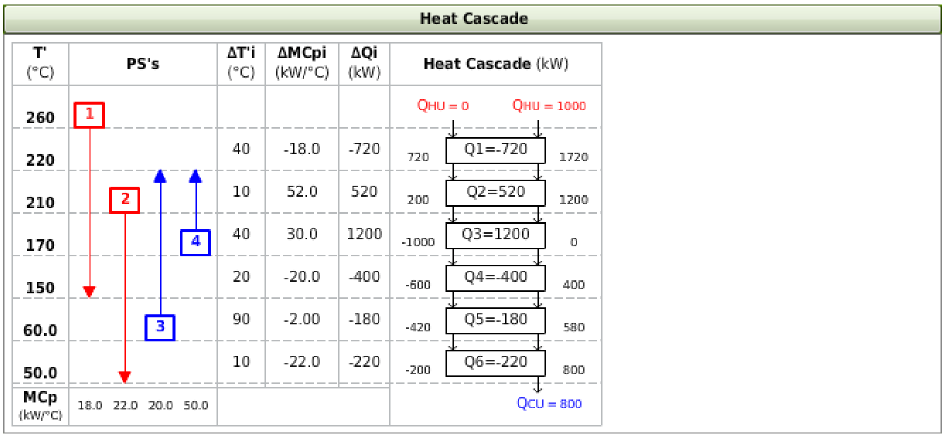



**Figure 31 – Heat Cascade representation**

The cascade gives information akin to the *Composite Curves*.

### Global Composite Curve window

In the *Global Composite Curve* window, the global composite curve is displayed right after *ΔTmin* and *Process Streams* and *Utilities* input.

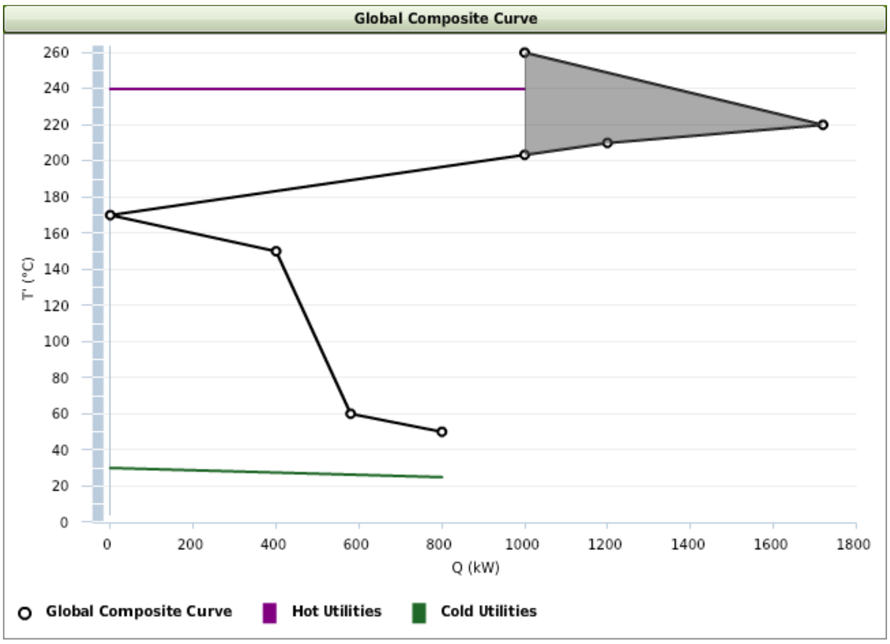



**Figure 32 – Global Composite Curve representation**

In the *Data* tab, the global composite curve assembly is achieved by using the utilities that were previously added by the user, with the aim of minimising the utilities' energy cost.

### HEN without Integration window

In the *HEN without Integration* window, in the *Data* tab, it is drawn the HEN without Integration, *i.e.*, FI2EPI assumes that all the process streams are fulfilled by the utilities given by the user.

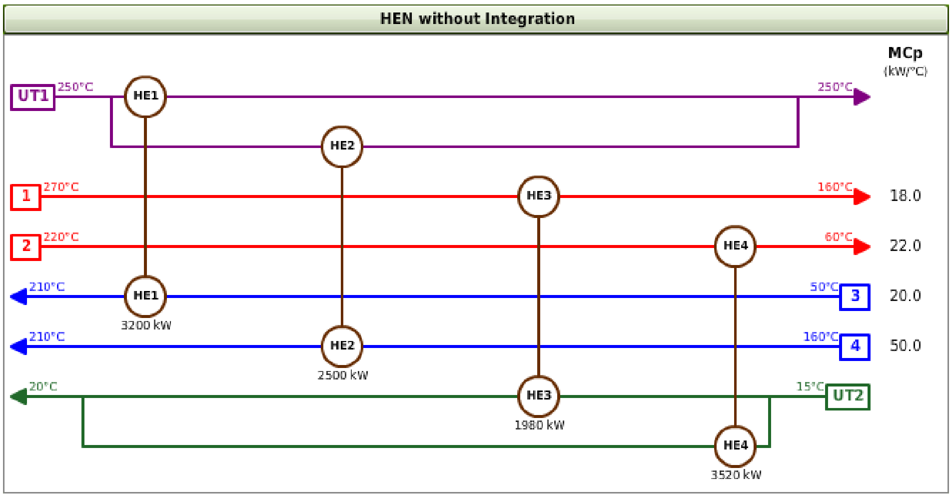



**Figure 33 – HEN without Integration completely fulfilled**

If there are no utilities that allow the ΔTmin value to be respected, the process streams will become dashed.

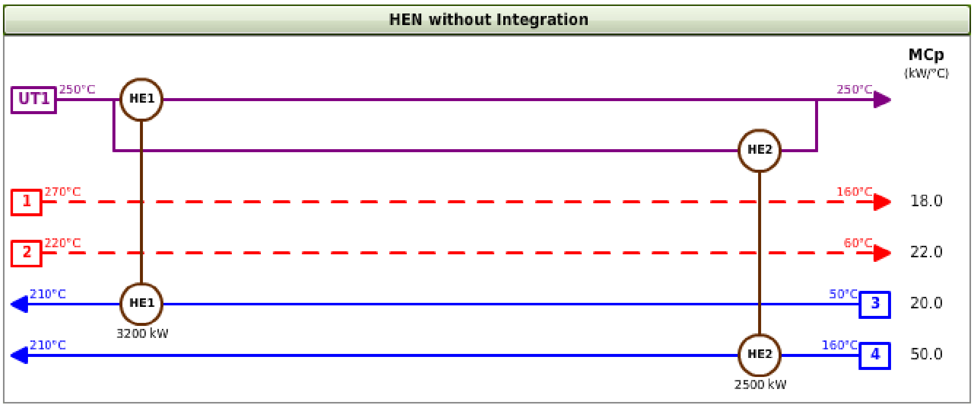



**Figure 34 - HEN without Integration with unfulfilled streams**

In case there are more than one cold or hot utility, the warmest hot utility and the coldest cold utility are used, by default.

### Existing Network window

In the Existing Network window in the *Data* tab, the existing heat exchanger network is drawn, including the exchangers that were added in the *Existing HE* window.

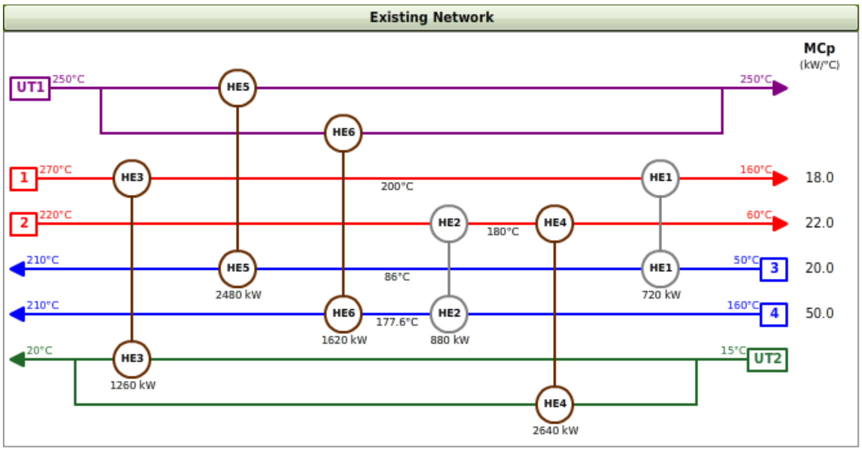



**Figure 35 – Existing Network completely fulfilled**

**Note:** If the *Utilities* have not been marked as "Existing" in the respective table, it will not be possible to add exchangers with utilities and, consequently, the streams would not be satisfied and would appear dashed in the existing network as shown in Fig. 36.

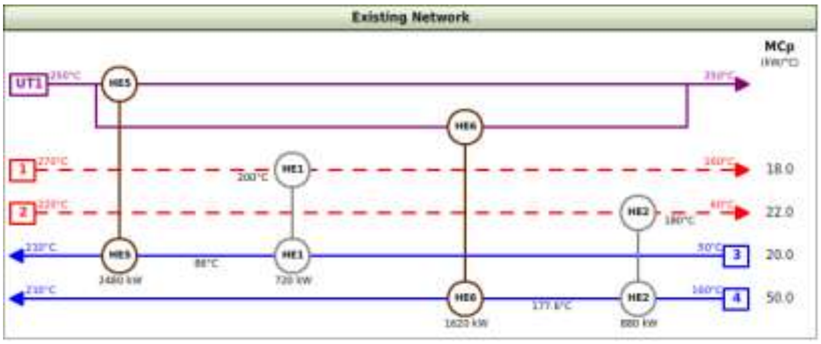



**Figure 36 – Existing Network with unfulfilled streams**

## 6. HEN without Integration tab

This tab refers to the *HEN without Integration*, which can be seen on the left side of the working area of Fi²EPI and. On the right side, the *Heat Cascade*, the *Composite Curves*, the *Global Composite Curve (HEN without Integration)* and the several *Costs* associated with this network are also displayed.

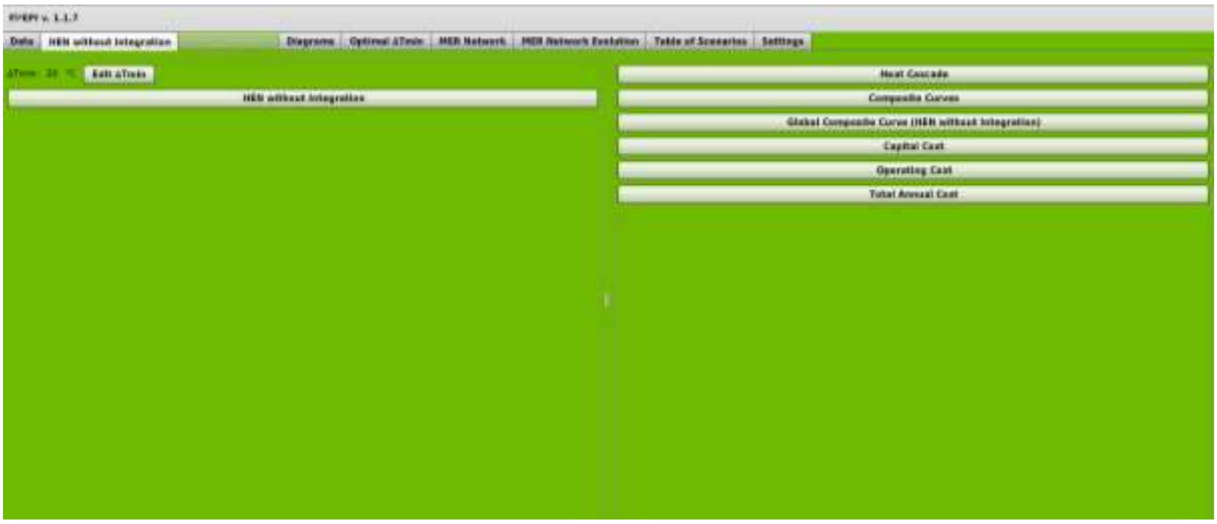



**Figure 37 – The HEN without Integration tab**

It is possible to edit the *ΔTmin* value, although one should bear in mind that it will be changed in all tabs.

### Global Composite Curve (HEN without Integration) window

The Global Composite Curve (*HEN without Integration*) appears in the window with the same name. It differs from the one presented in the *Data* tab because it reflects the situation of *HEN without Integration*, *i.e.*, it indicates the potential for thermal duty saving that might be accomplished with energy integration.

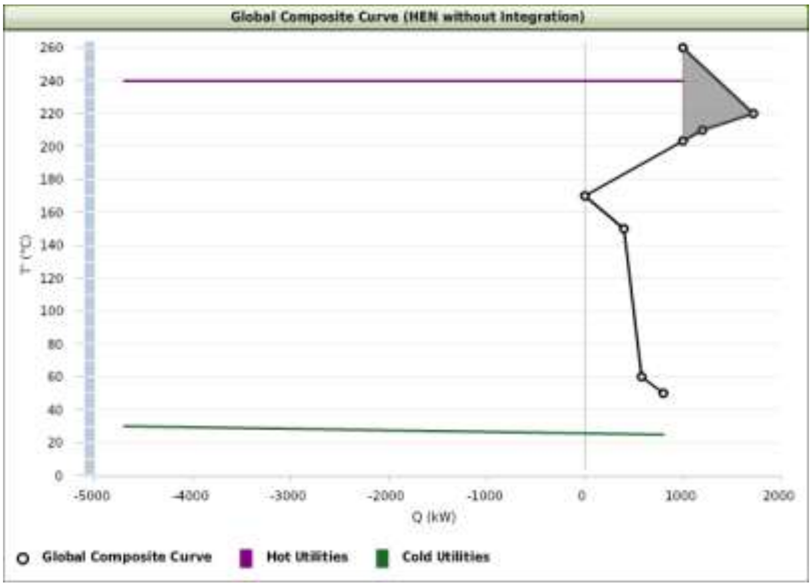



**Figure 38 - Global Composite Curve for the HEN without Integration**

### Capital Cost window

In the Capital Cost window, the heat exchanger cost of the network without integration is computed and displayed in a table, according to the cost laws on *Economic Data*, where the area of each exchanger is computed based on the heat exchanged and temperatures of each exchanger.

| Capital Cost | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hot | | Cold | | Q | U | ΔTln | Calculated | Calculated |
| | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | (kW) | (kW/m²·°C) | (°C) | Area (m²) | Cost (€) |
| **HE1** | 250 | 250 | 50.0 | 210 | 3200 | 0.42 | 99.4 | 77.3 | 69077.11 |
| **HE2** | 250 | 250 | 160 | 210 | 2500 | 0.42 | 61.7 | 97.3 | 83118.14 |
| **HE3** | 270 | 160 | 15.0 | 20.0 | 1980 | 0.33 | 192.8 | 30.8 | 36571.20 |
| **HE4** | 220 | 60.0 | 15.0 | 20.0 | 3520 | 0.33 | 103.9 | 102 | 86137.50 |
| | | | | | | | | **Total Cost:** | **274903.95** |

**Figure 39 – Capital Cost table for the HEN without Integration scenario**

### Operating Cost window

In the Operating Cost window, the hourly costs are obtained regarding the consumption of utilities, using the price defined by the user on the *Utilities* specification.

| Operating Cost | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Description** | | Ti (°C) | Tf (°C) | Q (kW) | M (kg/h) | Hourly Cost (€/h) | Total Cost (€/h) |
| **UT1** | **High Pressure Steam** | **HE1** | 250 | 250 | 3200 | 6715 | 65.31 | 116.33 |
| | | **HE2** | | | 2500 | 5246 | 51.02 | |
| **UT2** | **Cold Water** | **HE3** | 15.0 | 20.0 | 1980 | 340727 | 0.71 | 1.98 |
| | | **HE4** | | | 3520 | 605736 | 1.27 | |
| | | | | | | | **Total Cost:** | **118.31** |

**Figure 40 – Operating Cost for the HEN without Integration scenario**

### Total Annual Cost window

In this window the HEN total annual costs without integration are presented. Those costs are: the *Capital Cost* per year, using the economic input parameters in the windows *Economic Data* and

*Operating Costs*, considering the input operating time in the economic parameters in the window *Economic Data*.

| Total Annual Cost | | | | | |
|---|---|---|---|---|---|
| **Capital Cost:** | | **Operating Cost:** | | **Total Annual Cost:** | |
| 61750.88 €/year | + | 1005609.00 €/year | = | 1067359.88 €/year | |

**Figure 41 – Total Annual Cost computation result for the HEN without Integration**

## 7. Existing Network tab

This tab speaks of the existing network that is exhibited on the left side of the Fi²EPI's working area. On the right side the *Composite Curves*, the *Heat Cascade*, the *Global Composite Curve (Existing Network)* and the *Costs* related to this network, are provided

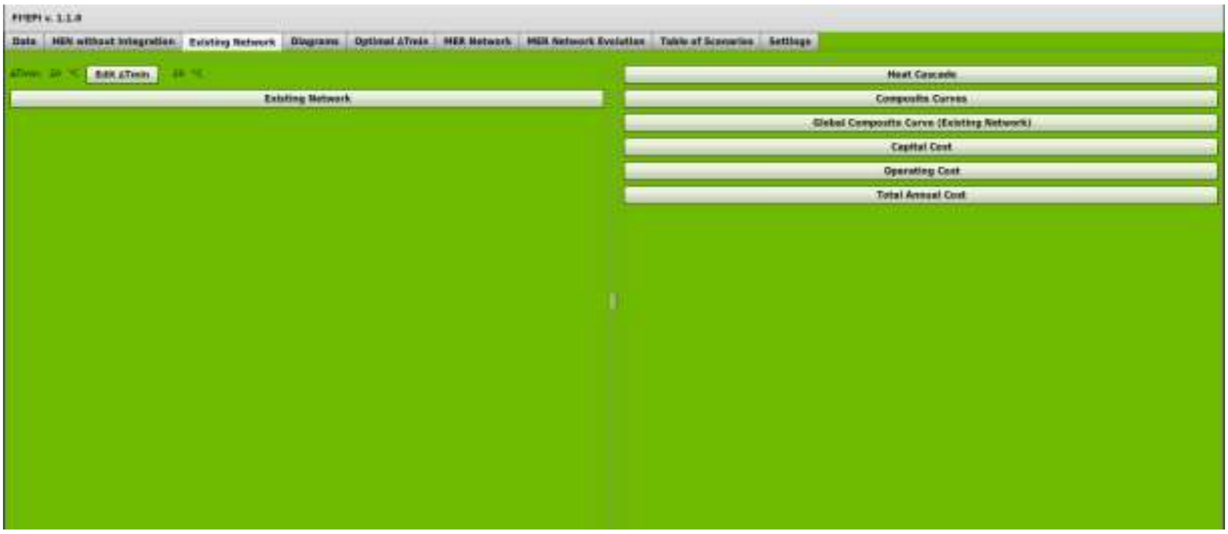



**Figure 42 – The Existing Network tab**

It continues to be possible to edit the *ΔTmin* value, but it will be altered in all tabs if one chooses to do so (see *Data* section).

The *Existing Network* represents the implemented heat exchanger network and consequently has an inherent ΔTmin.

The ΔTmin value of the existing network is displayed next to the button **Edit ΔTmin**. This value cannot be changed because it's a characteristic of the existing network.

### Global Composite Curve (Existing Network) window

The global composite curve of the existing network is displayed in Fi²EPI's working area on right side, in the *Existing Network* tab. This curve differs from the one beforehand obtained in the *Data* tab because it reflects the situation from the point of view of the *Existing Network*, *i.e.*, it indicates the remaining potential for integration for the provided *ΔTmin* value in the respective menu.

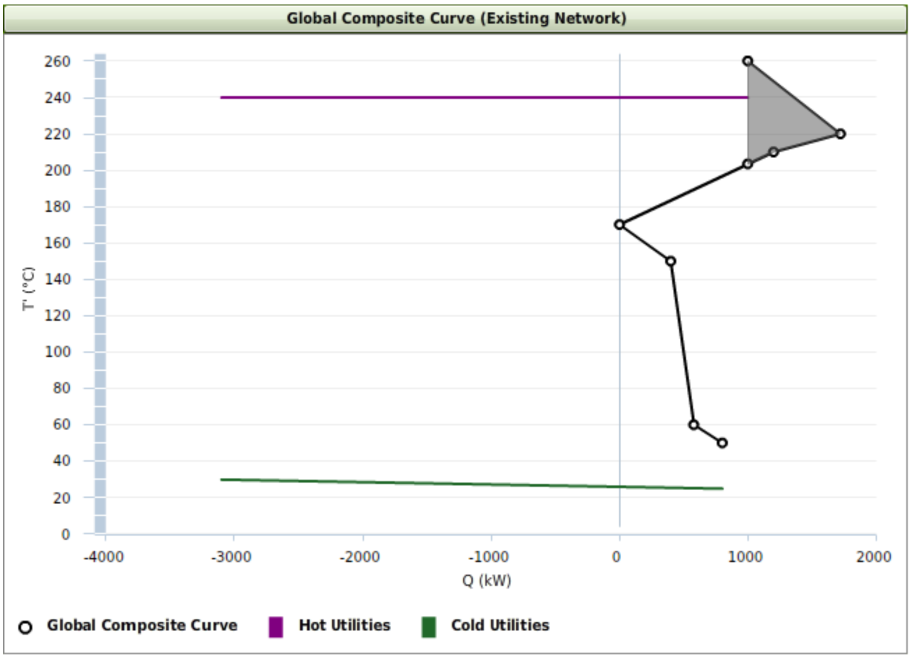



**Figure 43 – Global Composite Curve for the Existing Network**

### Capital Cost window

In the *Capital Cost* window, it's computed and assembled the heat exchangers' costs for the existing network in a table.

| Capital Cost | Hot | | Cold | | Q | U | ΔTln | Calculated | Calculated |
|---|---|---|---|---|---|---|---|---|---|
| | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | (kW) | (kW/m²·°C) | (°C) | Area (m²) | Cost (€) |
| **HE1** | 200 | 160 | 50.0 | 86.0 | 720 | 0.25 | 112 | 25.7 | 33001.91 |
| **HE2** | 220 | 180 | 160 | 178 | 880 | 0.25 | 29.8 | 118 | 97655.77 |
| **HE3** | 270 | 200 | 15.0 | 20.0 | 1260 | 0.33 | 215.9 | 17.5 | 27257.29 |
| **HE4** | 180 | 60.0 | 15.0 | 20.0 | 2640 | 0.33 | 90.7 | 87.4 | 76153.28 |
| **HE5** | 250 | 250 | 86.0 | 210 | 2480 | 0.42 | 87.9 | 67.7 | 62409.16 |
| **HE6** | 250 | 250 | 178 | 210 | 1620 | 0.42 | 54.6 | 71.2 | 64839.46 |
| | | | | | | | | **Total Cost:** | **361316.87** |

**Figure 44 - Capital Cost table for the Existing Network**

The value of the exchangers' cost and their respective area can be provided by the user when the existing heat exchangers' input is made, in the *Data* tab on the *Existing HE* window. In case these values (costs and areas) are provided by the user, they shall appear in the table as **Real Cost** and **Real Area** (Fig. 45).

| Capital Cost | Hot | | Cold | | Q | U | ΔTln | Calculated | Real | Calculated | Real |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | (kW) | (kW/m²·°C) | (°C) | Area (m²) | Area (m²) | Cost (€) | Cost (€) |
| **HE1** | 200 | 160 | 50.0 | 86.0 | 720 | 0.25 | 112 | 25.7 | 25.0 | 33001.91 | 33000.00 |
| **HE2** | 220 | 180 | 160 | 178 | 880 | 0.25 | 29.8 | 118 | 110 | 97655.77 | 95000.00 |
| **HE3** | 270 | 200 | 15.0 | 20.0 | 1260 | 0.33 | 215.9 | 17.5 | 17.5 | 27257.29 | 27500.00 |
| **HE4** | 180 | 60.0 | 15.0 | 20.0 | 2640 | 0.33 | 90.7 | 87.4 | 87.4 | 76153.28 | 78000.00 |
| **HE5** | 250 | 250 | 86.0 | 210 | 2480 | 0.42 | 87.9 | 67.7 | 65.0 | 62409.16 | 60000.00 |
| **HE6** | 250 | 250 | 178 | 210 | 1620 | 0.42 | 54.6 | 71.2 | 72.0 | 64839.46 | 65000.00 |
| | | | | | | | | | **Total Cost:** | **361316.87** | **358500.00** |

**Figure 45 - Capital Cost table for the Existing Network with Real Cost column**

If no real information is provided, those abovementioned values are to be determined by the cost law made available in *Economic Data*, within the *Data* tab. In this case, they will be described in the table as **Calculated Cost** and **Calculated Area** (Fig 45)

### Operating Cost window

In the *Operating Cost* window, the hourly costs of the utilities using the price previously inserted by the user in the window *Utilities* are obtained.

**Operating Cost**

| | Description | | Ti (°C) | Tf (°C) | Q (kW) | M (kg/h) | Hourly Cost (€/h) | Total Cost (€/h) |
|---|---|---|---|---|---|---|---|---|
| UT1 | High Pressure Steam | HE5 | 250 | 250 | 2480 | 5204 | 50.61 | 83.67 |
| | | HE6 | | | 1620 | 3400 | 33.06 | |
| UT2 | Cold Water | HE3 | 15.0 | 20.0 | 1260 | 216826 | 0.45 | 1.40 |
| | | HE4 | | | 2640 | 454302 | 0.95 | |
| | | | | | | | Total Cost: | 85.08 |

**Figure 46 – Operating Cost table for the Existing Network**

### Total Annual Cost window

This window displays the *Total Annual Cost* of the existing network, which significance comes from the *Capital Cost* per year, obtained using the interest rate economic parameter in the *Data* tab on the *Economic Data* window, and from the *Operating Costs* for one year, considering the user's input operating time in the economic parameters also on the *Economic Data* window.

**Total Annual Cost**

| Capital Cost: | | Operating Cost: | | Total Annual Cost: |
|---|---|---|---|---|
| 81161.57 €/year | + | 723161.00 €/year | = | 804322.57 €/year |

**Figure 47 - Total Annual Cost computation result for the Existing Network**

## *8. Diagrams tab*

The numerous diagrams obtained from the Pinch Methodology are displayed in the *Diagrams* tab, where one can engender several scenarios in the *Utility Scenarios* window on the working area's left side. The right side of the working area, has displayed the *Composite Curves*, the *Global Composite Curve*, the *Balanced Composite Curves* and the *Area Estimation* (Fig. 48).

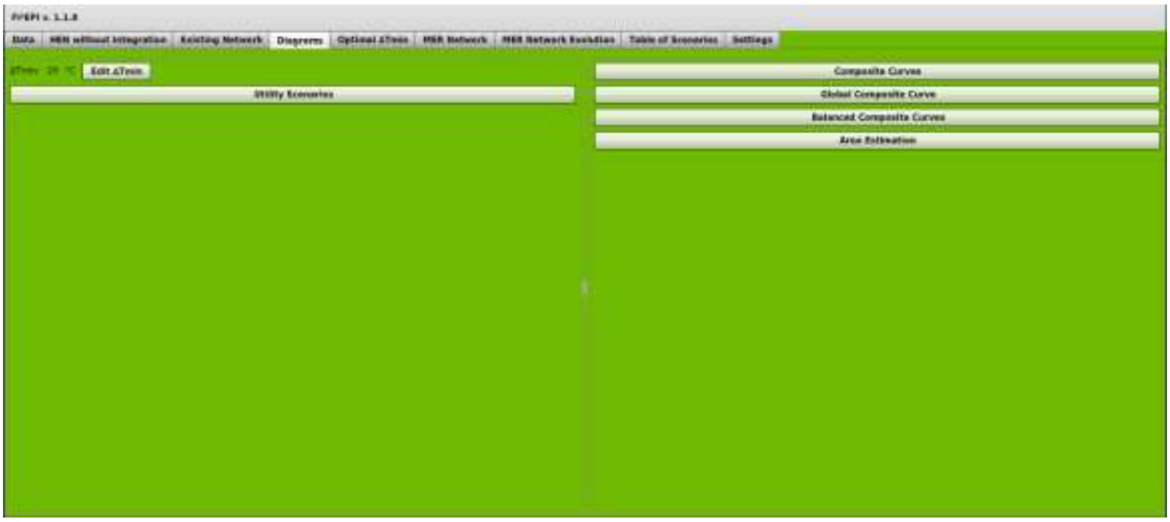
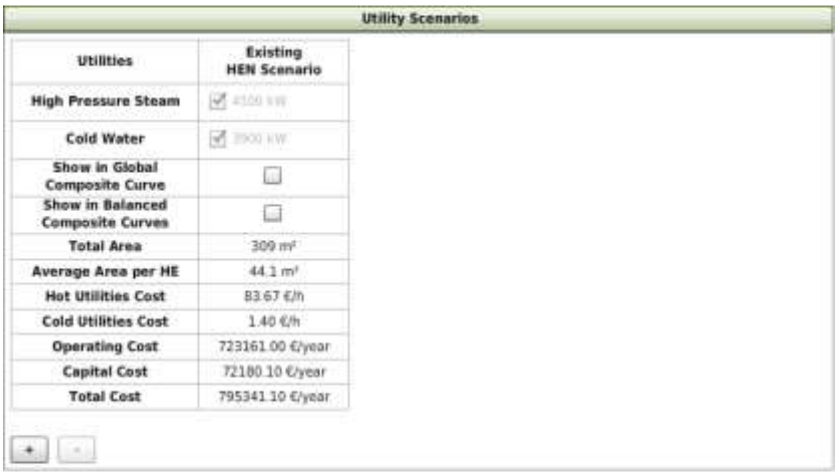



**Figure 48 – The Diagrams tab**

### Utility Scenarios window

Within the *Diagrams* tab one can find the *Utility Scenarios* window where it is possible to choose several utilities scenarios and obtain results for a total areal estimate, an average area per HE, the hourly and annually operating costs, the capital costs per year as well as the total cost.

Each and every time an *Existing Network* is defined, a default scenario is automatically generated for itself (Fig. 49).




| Utilities | Existing HEN Scenario |
|---|---|
| High Pressure Steam | 4100 kW |
| Cold Water | 2900 kW |
| Show in Global Composite Curve | |
| Show in Balanced Composite Curves | |
| Total Area | 309 m² |
| Average Area per HE | 44.1 m² |
| Hot Utilities Cost | 83.67 €/h |
| Cold Utilities Cost | 1.40 €/h |
| Operating Cost | 723161.00 €/year |
| Capital Cost | 72180.10 €/year |
| Total Cost | 795341.10 €/year |

**Figure 49 – The Utility Scenarios menu**

To add a scenario, click on **+** button and subsequently choose the utilities to be used.

**Utility Scenarios**

| Utilities | Existing HEN Scenario | Scenario 1 |
|---|---|---|
| High Pressure Steam | ☑ 4100 kW | ☑ 1000 kW |
| Cold Water | ☑ 3900 kW | ☑ 800 kW |
| Show in Global Composite Curve | ☐ | ☐ |
| Show in Balanced Composite Curves | ☐ | ☐ |
| Total Area | 309 m² | 632 m² |
| Average Area per HE | 44.1 m² | 90.2 m² |
| Hot Utilities Cost | 83.67 €/h | 20.41 €/h |
| Cold Utilities Cost | 1.40 €/h | 0.29 €/h |
| Operating Cost | 723161.00 €/year | 175918.00 €/year |
| Capital Cost | 72180.10 €/year | 122916.81 €/year |
| Total Cost | 795341.10 €/year | 298834.81 €/year |

\+ -

**Figure 50 - Utility Scenarios menu with Scenario 1**

The *Utilities* listed in the table were inputs provided by the user in the *Data* tab.

It is necessary to at least choose one cold utility and one hot utility that satisfy the streams' thermal duty requirements after integration with the intention of obtaining the results from the estimates (Fig. 50).

In Fig. 51 it's possible to tick the first box, **Show in Global Composite Curves**. By doing so, the selected utilities shall be represented in the *Global Composite Curve* window (right side of Fi²EPI's working are). Up to two scenarios can be displayed simultaneously.

**Utility Scenarios**

| Utilities | Existing HEN Scenario | Scenario 1 |
|---|---|---|
| High Pressure Steam | ☑ 4100 kW | ☑ 1000 kW |
| Cold Water | ☑ 3900 kW | ☑ 800 kW |
| Show in Global Composite Curve | ☑ | ☑ |
| Show in Balanced Composite Curves | ☐ | ☑ |
| Total Area | 309 m² | 632 m² |
| Average Area per HE | 44.1 m² | 90.2 m² |
| Hot Utilities Cost | 83.67 €/h | 20.41 €/h |
| Cold Utilities Cost | 1.40 €/h | 0.29 €/h |
| Operating Cost | 723161.00 €/year | 175918.00 €/year |
| Capital Cost | 72180.10 €/year | 122916.81 €/year |
| Total Cost | 795341.10 €/year | 298834.81 €/year |

\+ -

**Figure 51 - Utility Scenarios menu with Scenario 1 with required representations**

Additionally, *Balanced Composite Curves* (right side of Fi²EPI's working area), as well as the *Area Estimation* table of for each scenario will be displayed, shall the user tick the **Show in Balanced Composite Curves**' box (Fig. 51).

| Utility Scenarios | | |
|---|---|---|
| Utilities | Existing HEN Scenario | Scenario 1 |
| High Pressure Steam | ☑ 4100 kW | ☑ 1000 kW |
| Cold Water | ☑ 3900 kW | ☑ 800 kW |
| Show in Global Composite Curve | ☑ | ☑ |
| Show in Balanced Composite Curves | ☐ | ☑ |
| Total Area | 309 m² | 632 m² |
| Average Area per HE | 44.1 m² | 90.2 m² |
| Hot Utilities Cost | 83.67 €/h | 20.41 €/h |
| Cold Utilities Cost | 1.40 €/h | 0.29 €/h |
| Operating Cost | 723161.00 €/year | 175918.00 €/year |
| Capital Cost | 72180.10 €/year | 122916.81 €/year |
| Total Cost | 795341.10 €/year | 298834.81 €/year |

+ -

**Figure 52 - Utility Scenarios menu with Scenario removal**

If one wants to eliminate a scenario, click in the **–** (*minus*) button. Note that the Existing HEN scenario cannot be disposed of.

### Global Composite Curve window

The previously selected utilities scenarios (in the *Utilities Scenarios* table) can be observed in this window. Recall that only up to two scenarios will appear at once (Fig. 53).

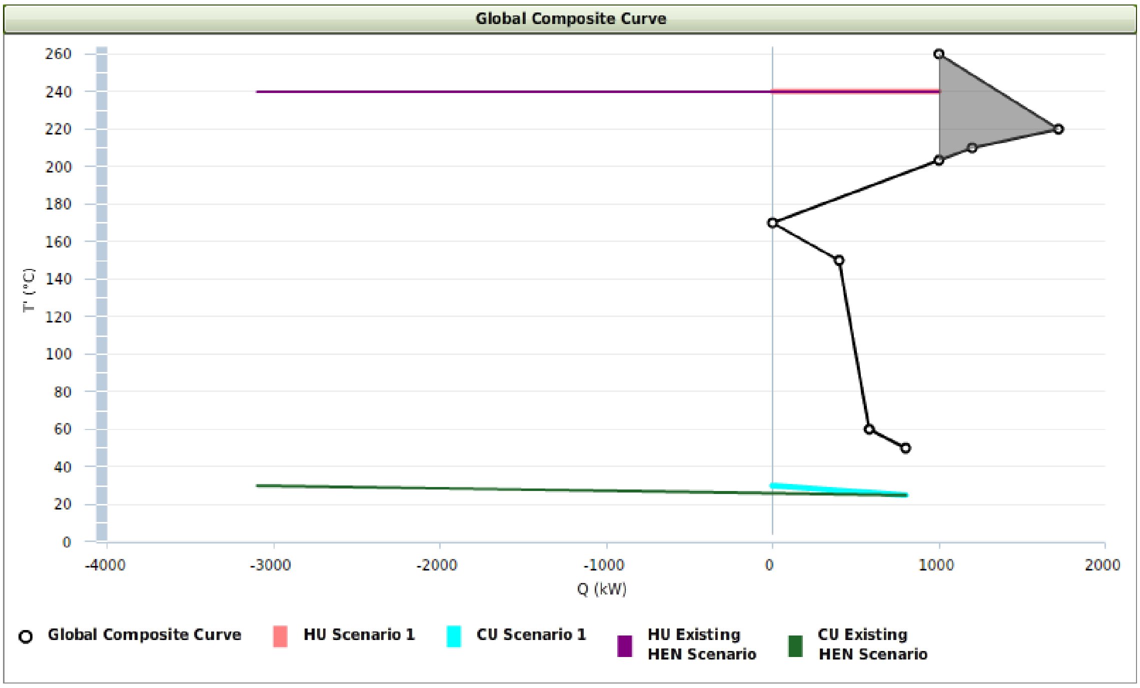



**Figure 53 – Global Composite Curve with Scenario representation**

### Balanced Composite Curves window

For the selected scenario in *Utilities Scenarios* table, the Balanced Composite Curves are displayed in this window.

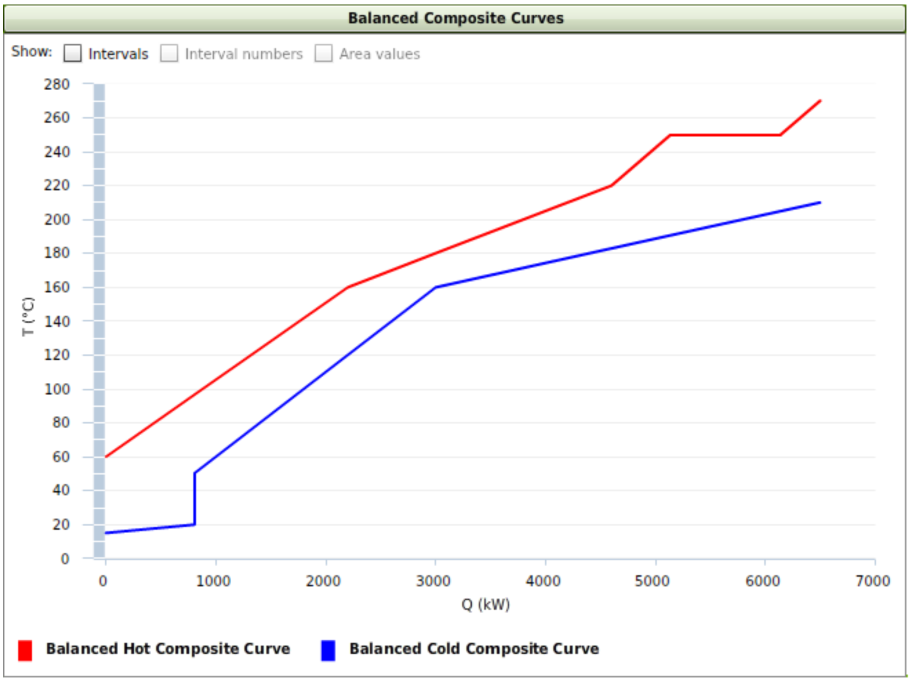



**Figure 54 – Balanced Composite Curves representation**

If none of the scenarios are selected, no curves should be drawn.

The *Balanced Composite Curves* will be divided in intervals and area estimate values, shall the user tick the **Show Interval** or **Interval numbers** or **Area estimation values** boxes, accordingly (Fig. 55).

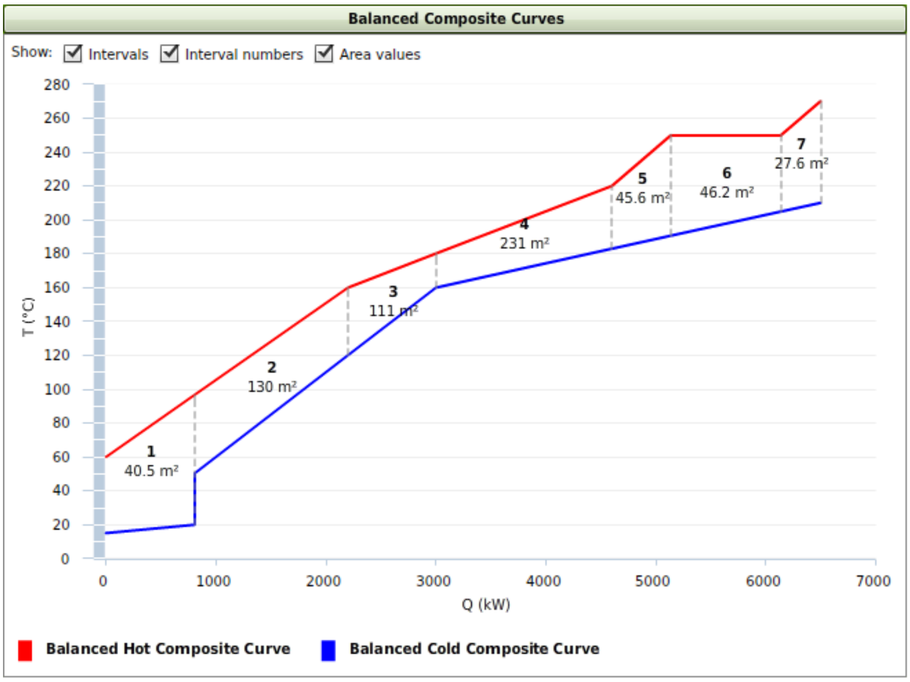



**Figure 55 – Balanced Composite Curves with Intervals, Intervals numbers and Area values displayed**

### Area Estimation window

This window has a dependence on *Balanced Composite Curves*, *i.e.*, if no scenario is selected then none of it is represented in the *Balanced Composite Curves* and thus the *Area Estimation* table will not become available.

Area Estimation

| | Hot | | Cold | | Hot ∑(Q/h) | Cold ∑(Q/h) | ΔTln | Area |
|---|---|---|---|---|---|---|---|---|
| | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | (m²·°C) | (m²·°C) | (°C) | (m²) |
| 1 | 96.4 | 60.0 | 15.0 | 20.0 | 1600 | 800 | 59.3 | 40.5 |
| 2 | 160 | 96.4 | 50.0 | 120 | 2800 | 2800 | 43.1 | 130 |
| 3 | 180 | 160 | 120 | 160 | 1600 | 1600 | 28.9 | 111 |
| 4 | 220 | 180 | 160 | 183 | 3200 | 3200 | 27.7 | 231 |
| 5 | 250 | 220 | 183 | 191 | 1080 | 1080 | 47.4 | 45.6 |
| 6 | 250 | 250 | 191 | 205 | 400 | 2000 | 52 | 46.2 |
| 7 | 270 | 250 | 205 | 210 | 720 | 720 | 52.2 | 27.6 |
| | | | | | | | Total Area: | 632 |

**Figure 56 – Area Estimation table**

The table shows each *Balanced Composite Curves* interval result. The computed values for each interval become available, namely: the interval temperature's edge, the mean logarithmic temperature difference and the interval's area estimate (Fig. 56).

## 9. Optimal *ΔTmin* tab

This tab refers to the optimal ΔTmin calculation. Within the *Optimization Conditions* window, on the working area's left side, it's defined the type of utilities, the range and temperature step variation to determine the Optimal ΔTmin. Several graphs can be pictured in the working area's right side, specifically: *Utilities vs. ΔTmin*, *Area vs. ΔTmin*, *Costs vs. ΔTmin*, *Costs vs. ΔTmin table* and *Optimization Result* (Fig.57).

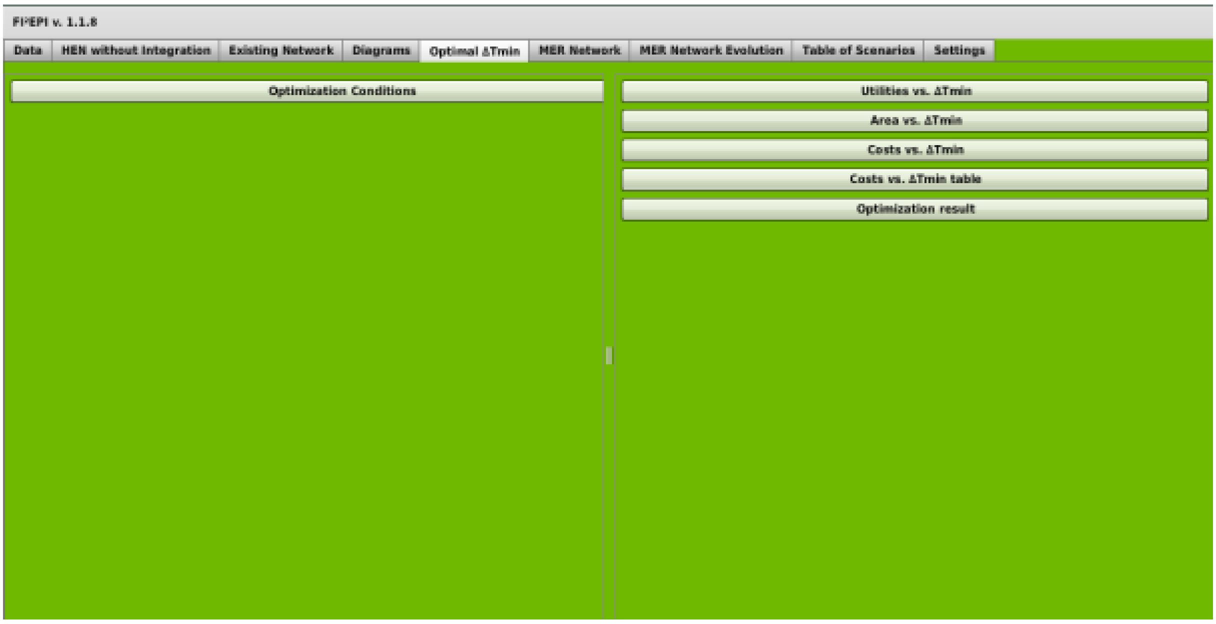



**Figure 57 – The Optimal ΔTmin tab**

### Optimization Conditions window

On the *Optimization Conditions* window, in the *Optimal ΔTmin* tab, the ΔTmin interval variation is used to determine the optimal value as a function of total costs per year (Capital + Operating).The user must indicate the **initial and final ΔTmin** as well as the optimisation **step** (Fig.58).

This window also allows the user to choose amongst the defined utilities in the *Utilities* window on the *Data* tab.

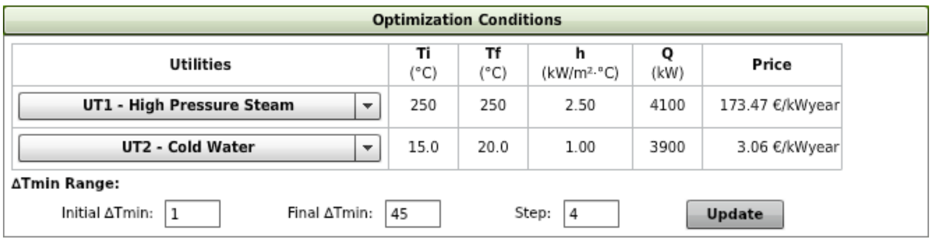



**Figure 58 – Optimization Conditions input window**

The **final ΔTmin** has to be higher than **initial ΔTmin** and has an allowed maximum value depending on the user's selected utilities. This limit is set forth by the *Global Composite Curve* observed on the *Data* tab.

Henceforward, when the user sets a **final ΔTmin** value that does not respect the aforementioned limit, a warning message will appear notifying the user about the allowed maximum value.

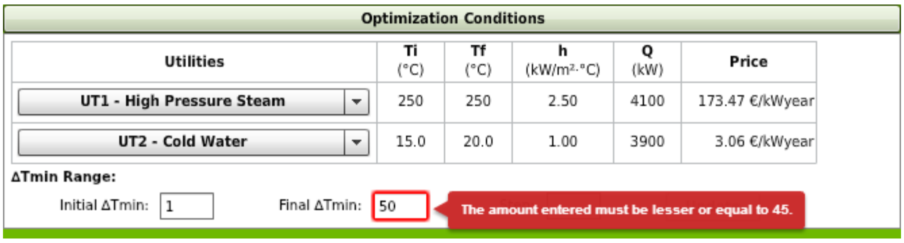



**Figure 59 – Final ΔTmin warning sign**

### Utilities vs. ΔTmin window

Subsequently to the *Optimization Conditions* input validation, a hot and cold utilities as a function of ΔTmin graph is displayed (Fig. 60).

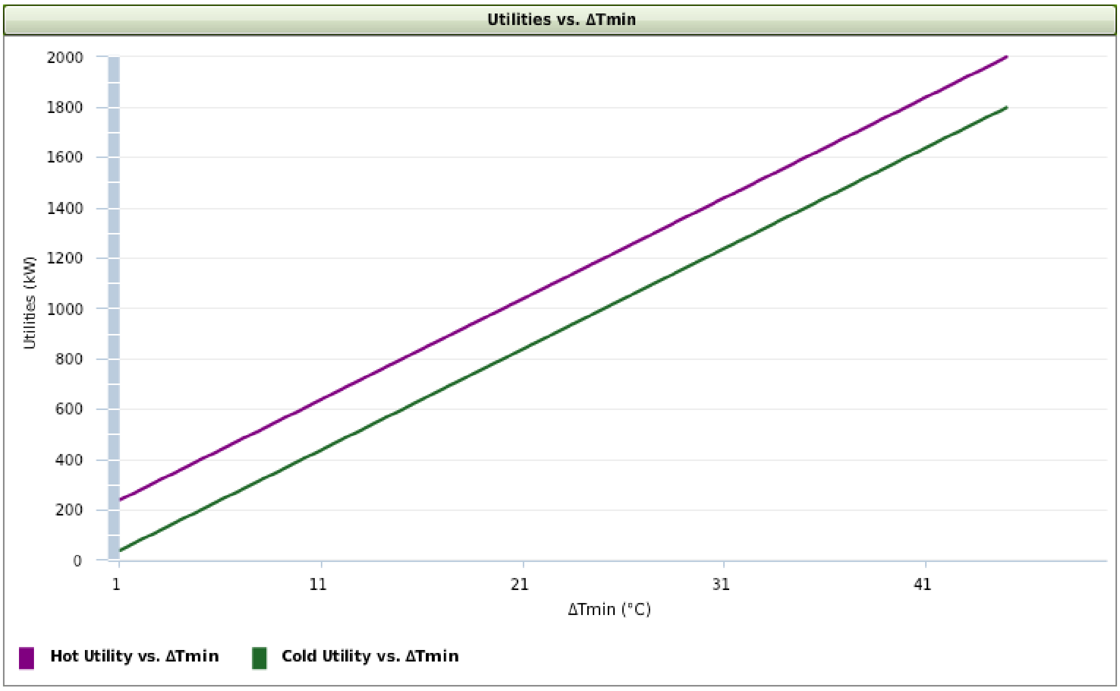



**Figure 60 – Utilities vs. ΔTmin graph**

### Area vs. ΔTmin window

After the *Optimization Conditions* input validation, a total area as a function of ΔTmin graph is displayed (Fig. 61).

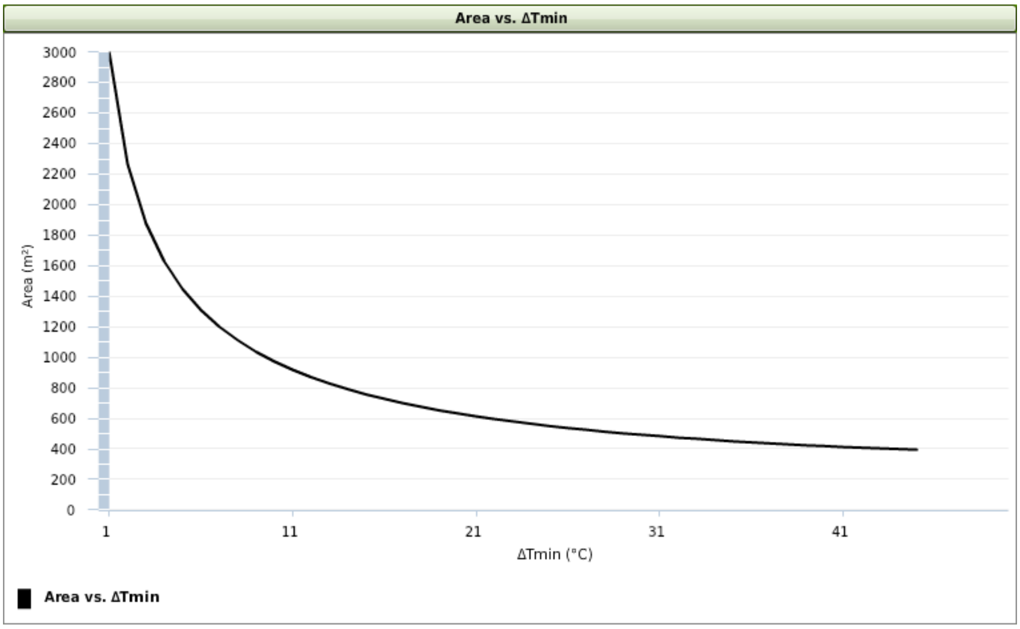



**Figure 61 – Area vs. ΔTmin graph**

### Costs vs. ΔTmin window

Later the *Optimization Conditions* input validation the optimal ΔTmin is achieved using this graph representation which has the operating costs, the total capital costs and the total annual costs as a function of ΔTmin (Fig. 62).

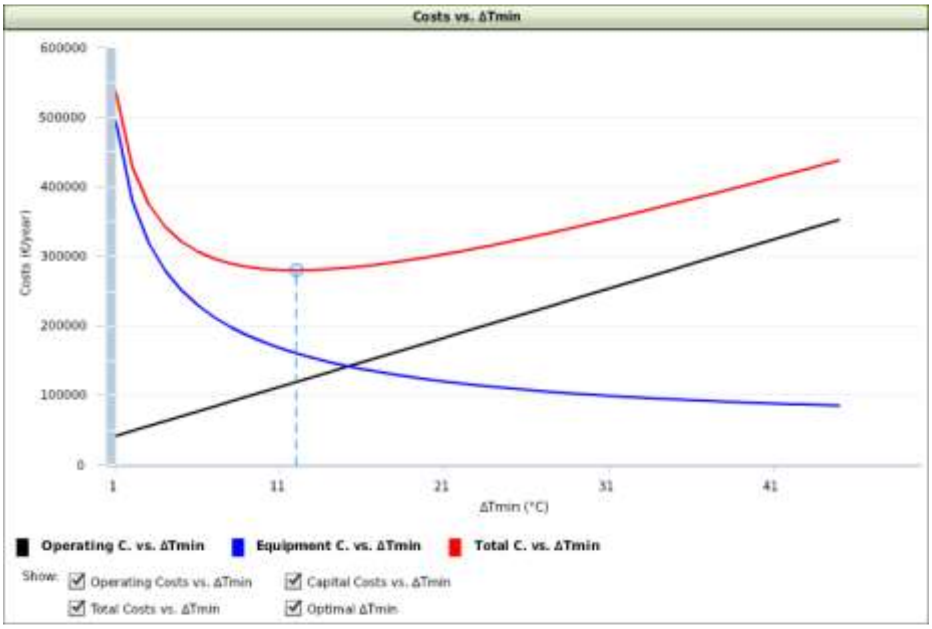



**Figure 62 – Costs vs. ΔTmin graph**

### Costs vs. ΔTmin table window

A summary table with the energy consumption, the minimum expected area and the costs related to each ΔTmin is given in this window. The table is built according to the step defined in the *Optimization Conditions* window.

**Costs vs. ΔTmin table**

| ΔTmin (°C) | CU (kW) | HU (kW) | CU Annual Cost (€/year) | HU Annual Cost (€/year) | Annual Operating Costs (€/year) | Area (m²) | Capital Cost (€) | Annualized Capital Cost (€/year) | Total Cost (€/year) |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 40.0 | 240 | 122.40 | 41632.80 | 41755.20 | 2997 | 2202762.87 | 494800.26 | 536555.46 |
| **5** | 200 | 400 | 612.00 | 69388.00 | 70000.00 | 1447 | 1117824.61 | 251093.72 | 321093.72 |
| **9** | 360 | 560 | 1101.60 | 97143.20 | 98244.80 | 1036 | 830058.34 | 186453.61 | 284698.41 |
| **13** | 520 | 720 | 1591.20 | 124898.40 | 126489.60 | 828 | 684473.12 | 153751.22 | 280240.82 |
| **17** | 680 | 880 | 2080.80 | 152653.60 | 154734.40 | 700 | 594851.17 | 133619.70 | 288354.10 |
| **21** | 840 | 1040 | 2570.40 | 180408.80 | 182979.20 | 613 | 533859.97 | 119919.42 | 302898.62 |
| **25** | 1000 | 1200 | 3060.00 | 208164.00 | 211224.00 | 550 | 489736.63 | 110008.13 | 321232.13 |
| **29** | 1160 | 1360 | 3549.60 | 235919.20 | 239468.80 | 502 | 456480.47 | 102537.89 | 342006.69 |
| **33** | 1320 | 1520 | 4039.20 | 263674.40 | 267713.60 | 465 | 430672.94 | 96740.82 | 364454.42 |
| **37** | 1480 | 1680 | 4528.80 | 291429.60 | 295958.40 | 436 | 410208.59 | 92143.97 | 388102.37 |
| **41** | 1640 | 1840 | 5018.40 | 319184.80 | 324203.20 | 412 | 393713.00 | 88438.61 | 412641.81 |
| **45** | 1800 | 2000 | 5508.00 | 346940.00 | 352448.00 | 393 | 380247.58 | 85413.92 | 437861.92 |

**Figure 63 – Summary table for the Costs vs. ΔTmin**

### Optimization result window

Finally, the optimisation result that includes the optimal ΔTmin value, the capital and operating costs and the total cost is collected in this window.

**Optimization result**

Optimal ΔTmin = 12.0°C
Annual Operating Cost = 119428.40 €/year
Total Capital Cost = 713906.38 €
Annualized Capital Cost = 160362.73 €/year
Total cost = 279791.13 €/year

**Figure 64 – Optimization result summary window**

## 10. MER Network tab

On the *MER Network* tab, the construction of a MER Network is divided in an *above* pinch point (PP) zone and a *below* PP zone, both identified in the *Composite Curves*. On the working area's right side, a comparison between several networks is displayed, namely the *Existing Network*, the *MER network*, the *Heat Cascade*, the *Global Composite Curve (MER network)* and the *Composite Curves*.


**Figure 65 – MER Network tab**

### Above the Pinch point Zone window

Fi²EPI automatically identifies the near PP exchangers as one can see as yellow shading in Fig. 66. The feasible options (yellow highlighted) just have to be ticked by the user. If more heat has to be provided or removed from the process streams, the tool shall provide more ticking box options for the user to choose.

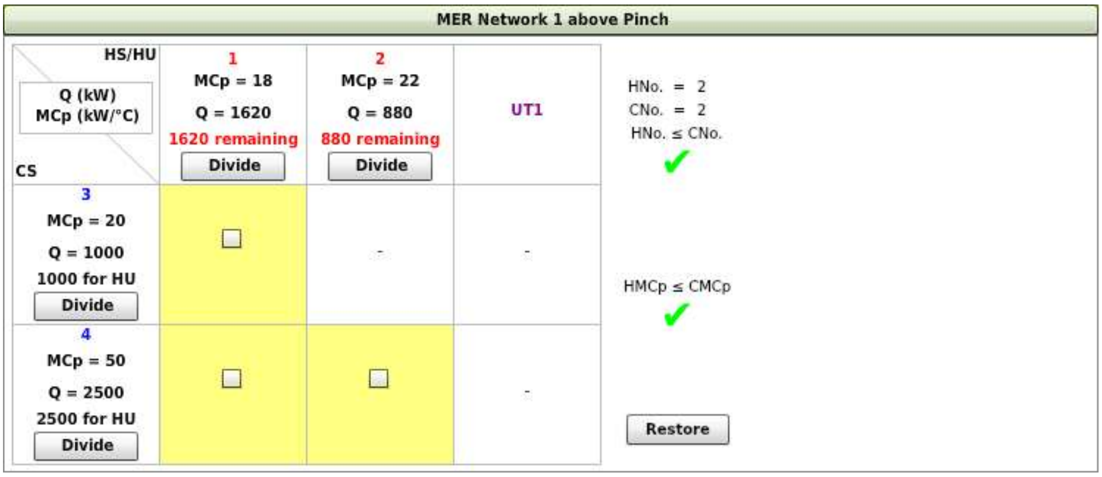



**Figure 66 – MER Network 1 above PP**

The user must select the remaining heat exchanges between process streams in order to complete the network, as well as the thermal duty value to be exchanged (Fig. 67).

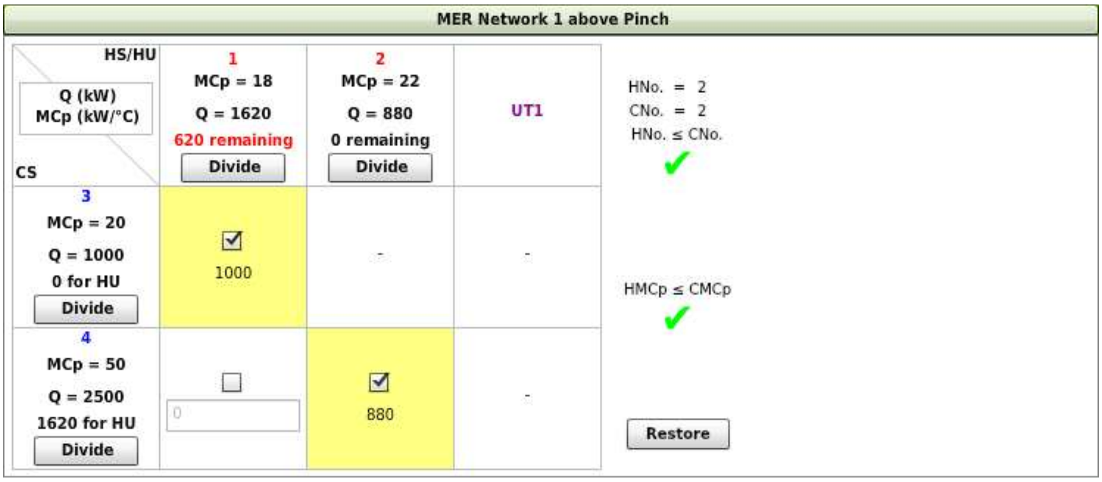



Figure 67 – MER Network 1 above PP (with 620kW yet to assign)

Once there is not to any further extent possible to place a exchanger, and the streams are yet to be fulfilled, one has the option to provide the network with exchangers with utilities as seen in Fig. 68.

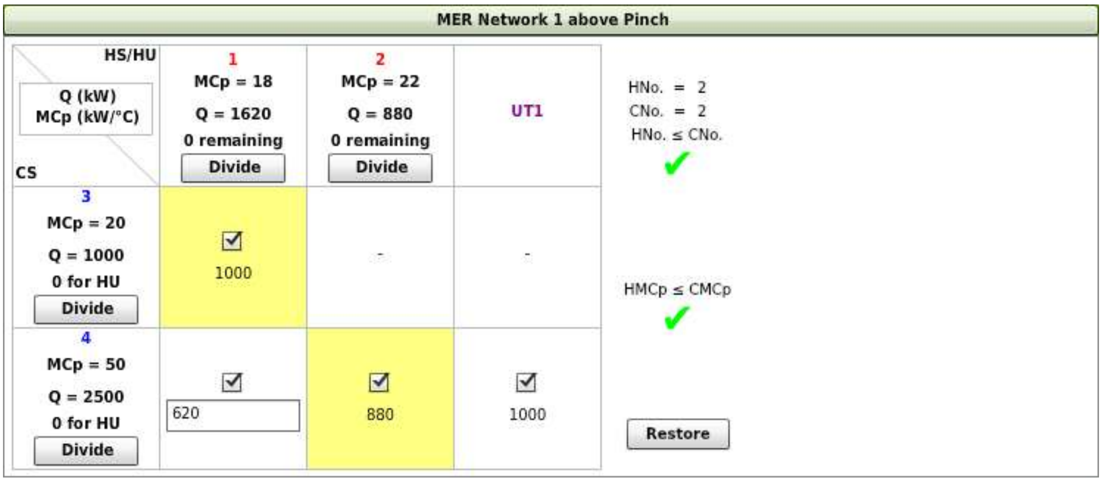



Figure 68 - Complete above PP MER Network 1 (with utility exchanger)

The user must choose the utilities to be used in the *MER Network*. To do so, on the *Data* tab in the *Utilities*' window, it is required to tick the *Using in MER network's* box.

The MER network is displayed on the working area's right side within the *MER network* window.

**Note:** If there are no utilities marked as *Using in MER network* and/or if the chosen utilities violate the ΔTmin criteria, the non-fulfilled streams shall appear dashed in the *MER network*.

### Below the Pinch Point Zone window

The *below PP* construction follows the same pattern as the *above PP* construction, as seen in Fig. 69.

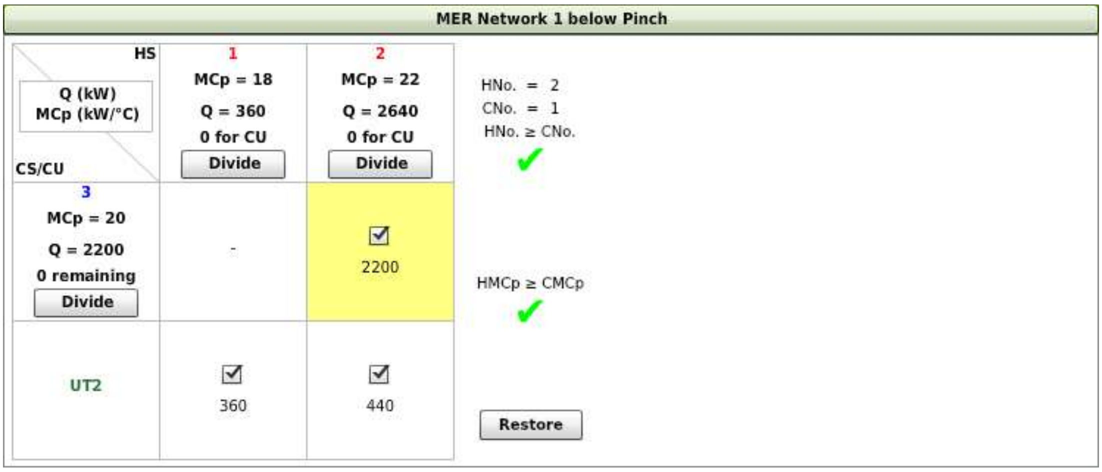



**Figure 69 - Complete below PP MER Network 1 (with utility exchanger)**

### Division of streams

The process streams' division of the MER network occurs when one of the methodology rules is not respected, whether it is the streams number or the MCp.

To illustrate the streams' division procedure, ***Example 2*** is used (obtained by accessing the **Project**/**Open** menu). In the said example, the MCp rule is not respected, for a ΔTmin of 5ºC as one can see by the red cross (✖) in Fig. 70.

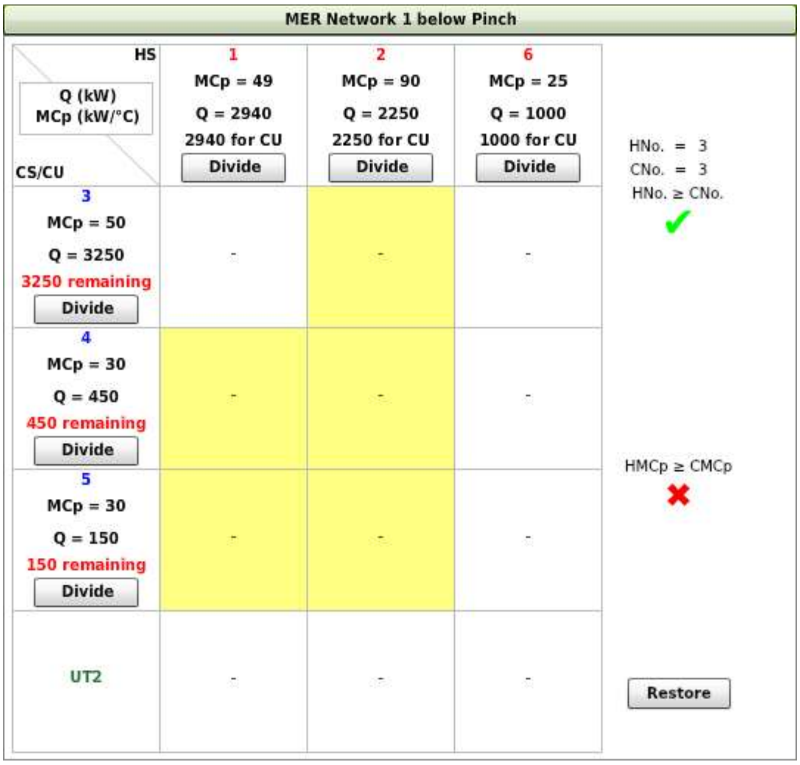



**Figure 70 – Example 2 below PP MER Network 1**

In these cases, the methodology recommends the division of the highest MCp cold stream (stream 3 for **Example 2**).


**Figure 71 - Example 2 below PP MER Network 1 with cold stream division**

After dividing stream 3, the streams' rule is no longer respected. In this case, it is necessary to divide the highest MCp hot stream (stream 2 for **Example 2**).

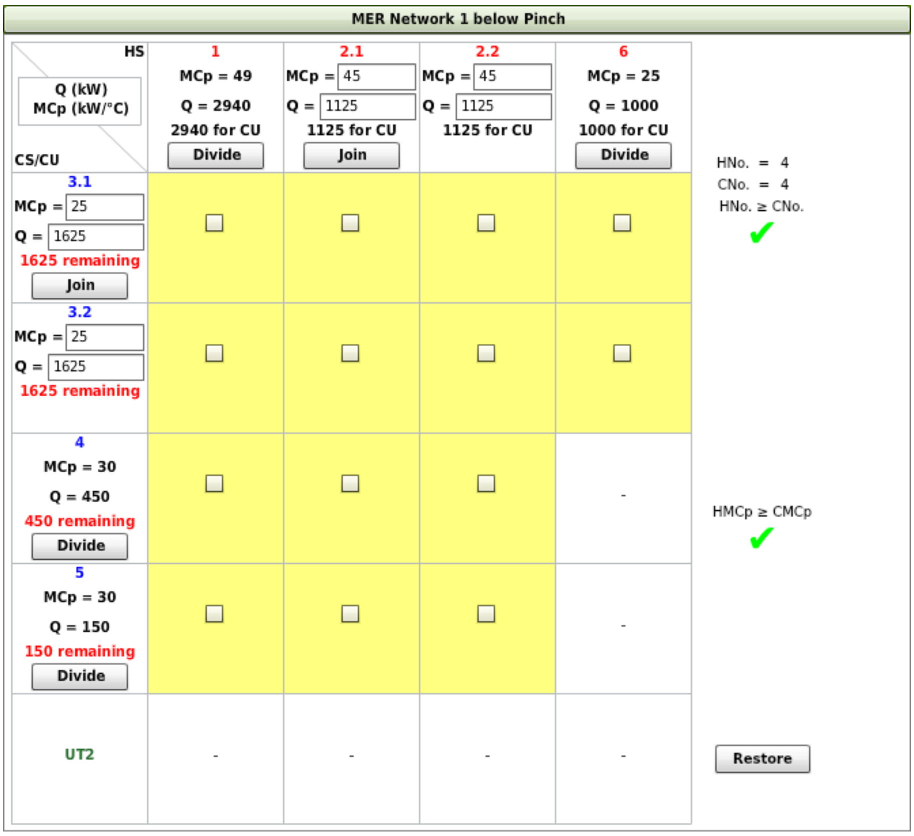



**Figure 72 - Example 2 below PP MER Network 1 with cold and hot stream division**

Subsequently to stream division, a second stream emerges from the first one. Fi²EPI suggests equitable MCp and heat duty division, but those values can be changed as pleased as one can see in Fig. 73.


**Figure 73 - Example 2 below PP MER Network 1 with stream division and non-equitable MCp values**

After all the necessary changes respecting stream division are performed (one can see all rules are respected by noticing the green tick (✓) in Fig. 73), it is possible to start ticking the heat exchangers' boxes (Fig. 74).

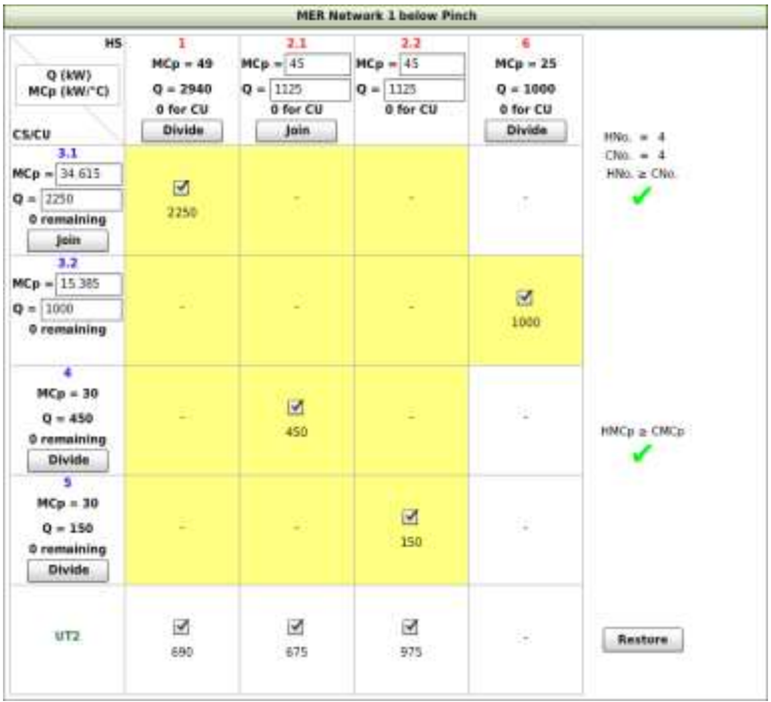



**Figure 74 – Complete MER Network 1 with stream division and non-equitable MCp values**

The final MER network shows the divided streams, as well as its MCp values and all the heat exchangers chosen.

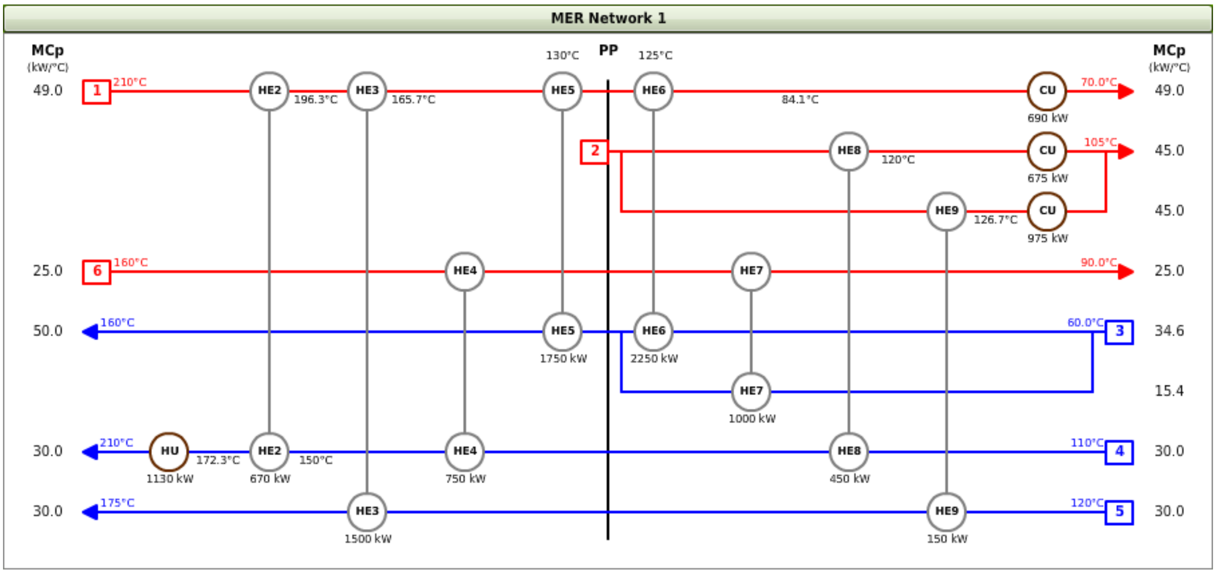



**Figure 75 – Complete MER Network 1 with stream division and non-equitable MCp values**

### MER Network window

In the *MER Network* window, the MER network built in this tab, as well as *above the PP* and *below the PP* windows are displayed.

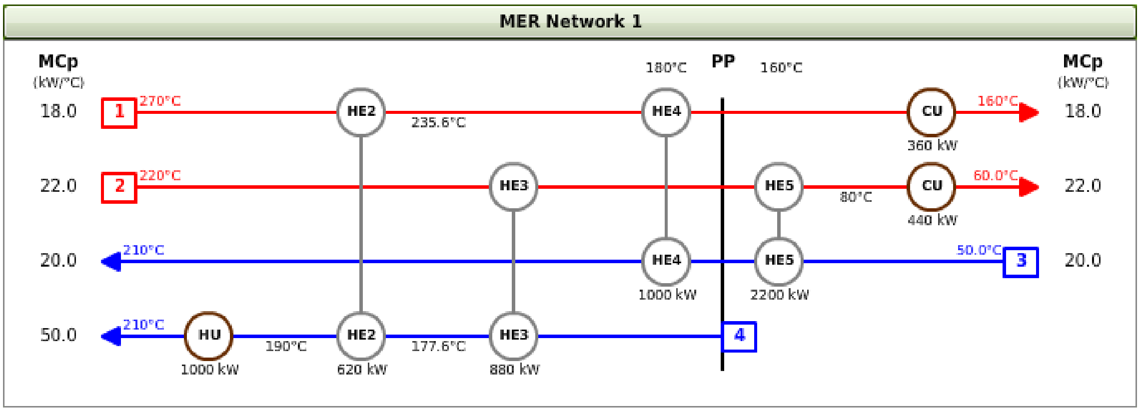



**Figure 76 – MER Network 1**

### Global Composite Curve (MER Network) window

On the *MER Network* tab, Global Composite Curve (MER Network 1) window shows, on its right side, the global composite curve of MER Network. This curve differs from the one shown on the Data tab, since it considers the MER Network situation, i.e., considering it indicates the utilities that are effectively used on the construction of said network.

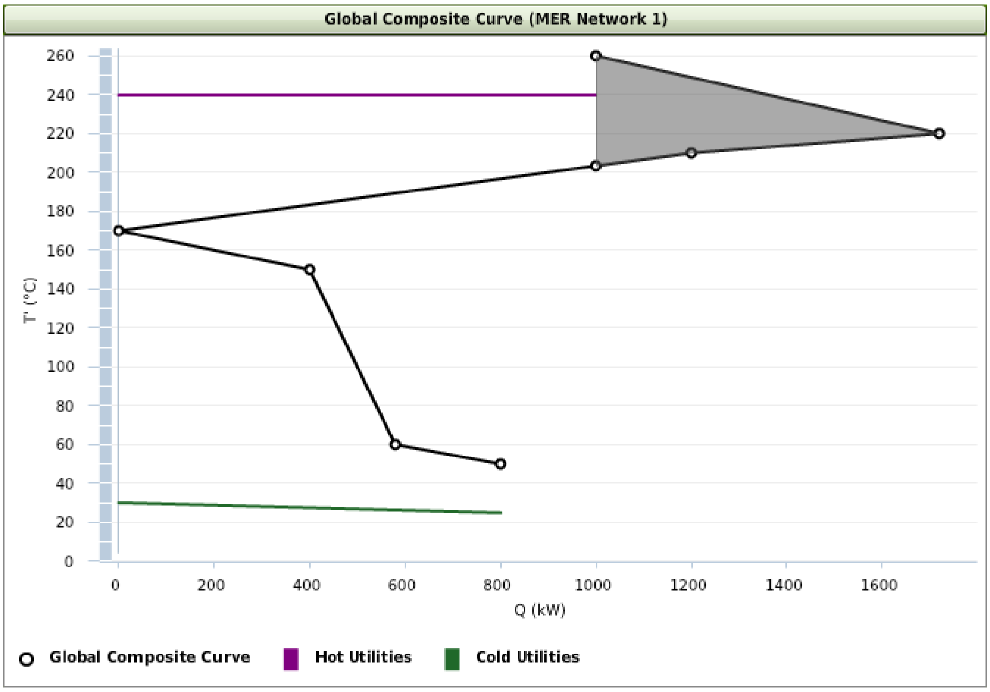



**Figure 77 – Global Composite Curve (MER Network 1)**

## 11. MER Network Evolution tab

On the *MER Network Evolution* tab, all the evolution scenarios of the MER Network considered to reduce the number of exchanging units and the corresponding cost are displayed. On the left side of the window, under *"Loops at MER Network"* (Fig. 78), there is a list of all possible loops on that MER Network. If you select a loop to be removed, other windows appear, showing the corresponding evolutions scenarios, including a list of alternative loops and energy paths. On the right side of $Fi^2EPI$'s working area, *Existing Network*, the *MER network* and the *Network of several scenarios* under construction appear.

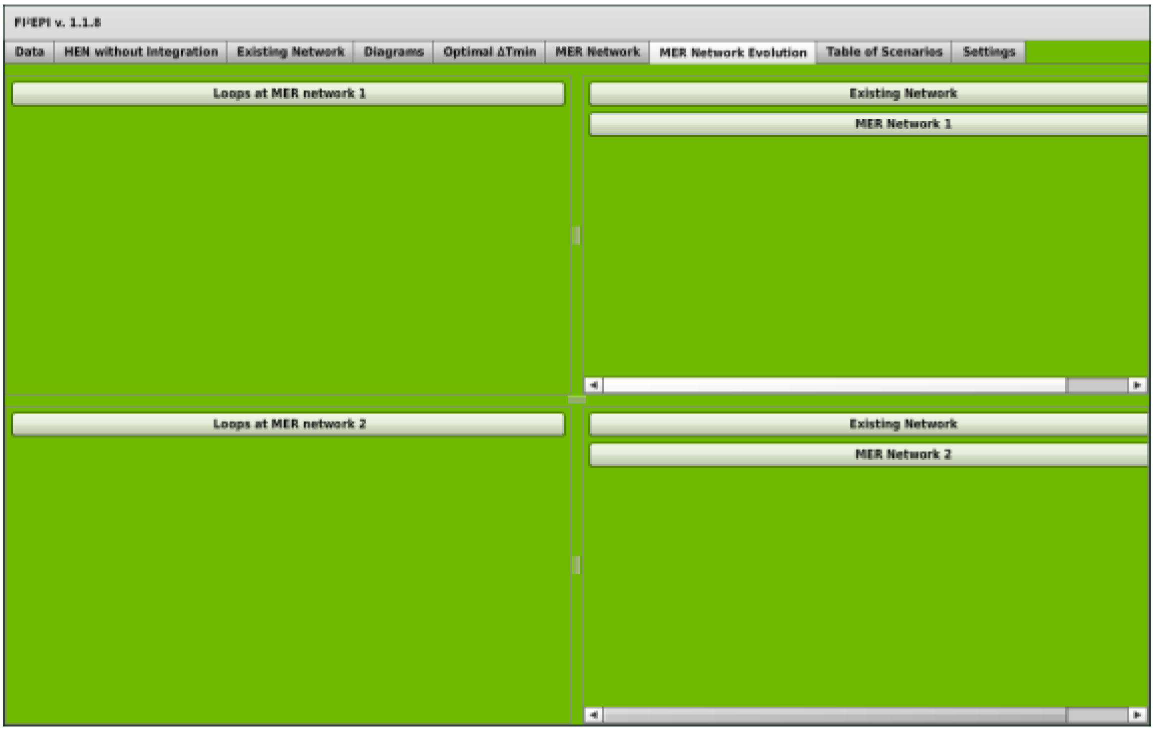



**Figure 78 – MER Network Evolution tab**

### Loops at MER network window

In *Loops at MER Network* window, existing loops in the MER network built on the *MER Network* tab appear (Fig. 79).

To remove a loop, select the loop and click the **Remove** button.

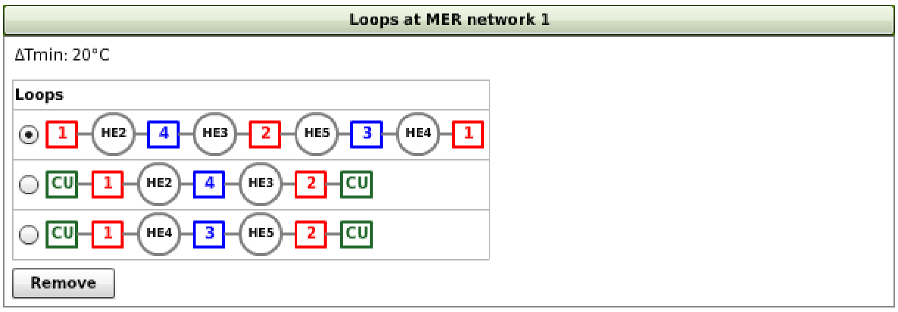



**Figure 79 - Loops at MER Network**

After removing the first loop, a new window opens on the right side of the screen, showing the corresponding scenario from which a heat exchanger was removed.

At the same time, another new window related to scenario 1 appears on the left side, identifying the exchangers that do not respect the initial ΔTmin indicating the cases of possible violations and impossible to ΔTmin. In order to restore the ΔTmin, Fi²EPI lists the alternative energy paths. One of said paths must be chosen and the Perform Heat Shifting button pushed, so that the new scenario network appears in a new window (Fig. 80).

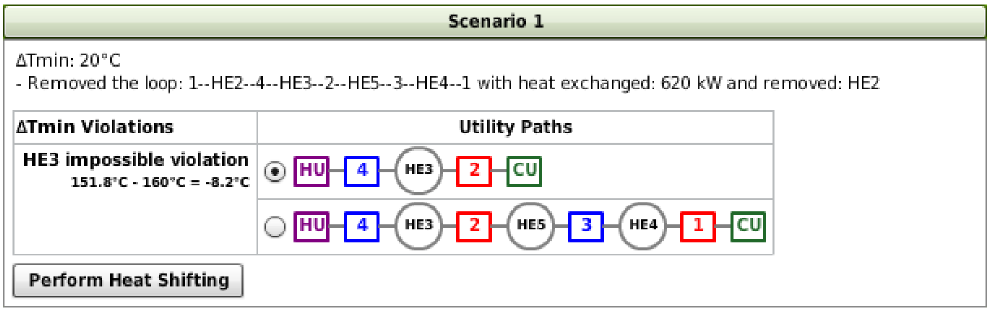



**Figure 80 - Scenario 1 with several utility paths**

There may be as many evolution scenarios as choices made. This evolution process shall end when no more loops appear or when no more/other heat shifting is possible.

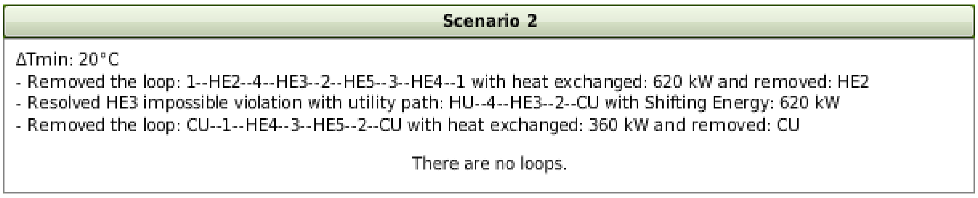



**Figure 81 - Scenario 2 (all loops and violations are gone)**

### MER Network window

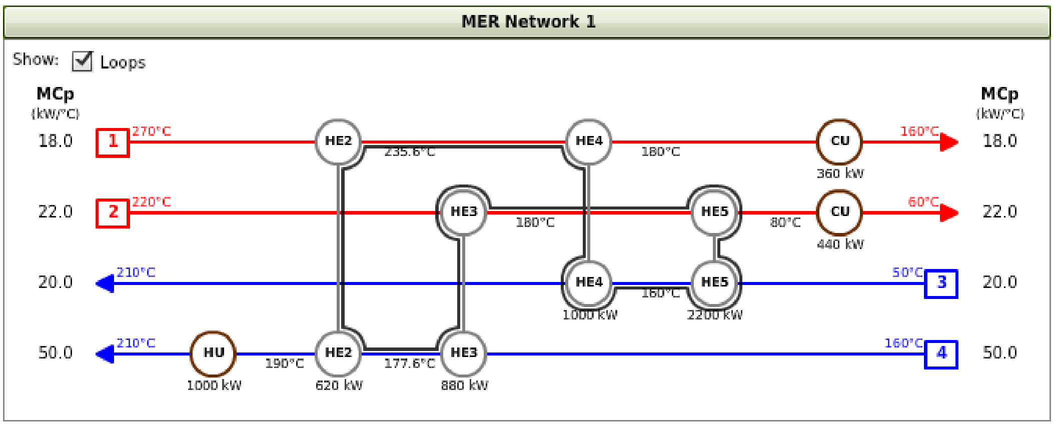



**Figure 82 – One of MER Network 1 Loops**

In the *MER Network* window, the MER Network built in the *MER Network* tab is shown.

In the *Loops at MER network* window, by clicking on the different loops, it is possible to see the cycle trace that is selected on the MER Network.

### Network Scenarios 1, 2, 3... windows

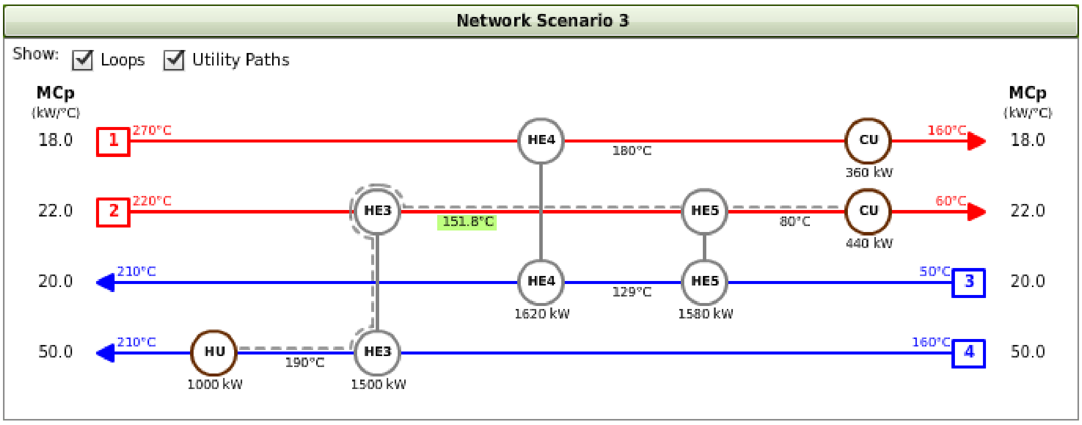



**Figure 83 - Network Scenario 3**

*Network Scenarios* windows always appear when a loop is opened and/or a heat shifting is performed (Fig. 83).

In the *Network Scenarios* window, by ticking the Loops/Utility Paths boxes, next to "**Show**", it is possible to hide or show the loops that are selected in the window of the corresponding scenario, on the left side of the working area.

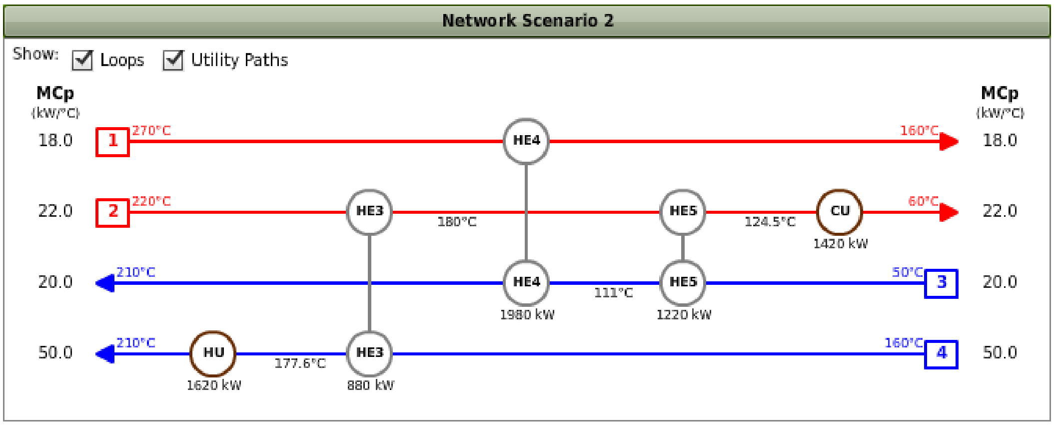



**Figure 84 - Network Scenario 2 without loops**

## 12. *Table of Scenarios tab*

On the *Table of Scenarios* tab, all scenarios previously obtained are listed, being the main features of all the scenarios summarised on the left side of the screen. On the right side of Fi²EPI's working area, an extended summary of every scenario's features of each corresponding network, is shown.

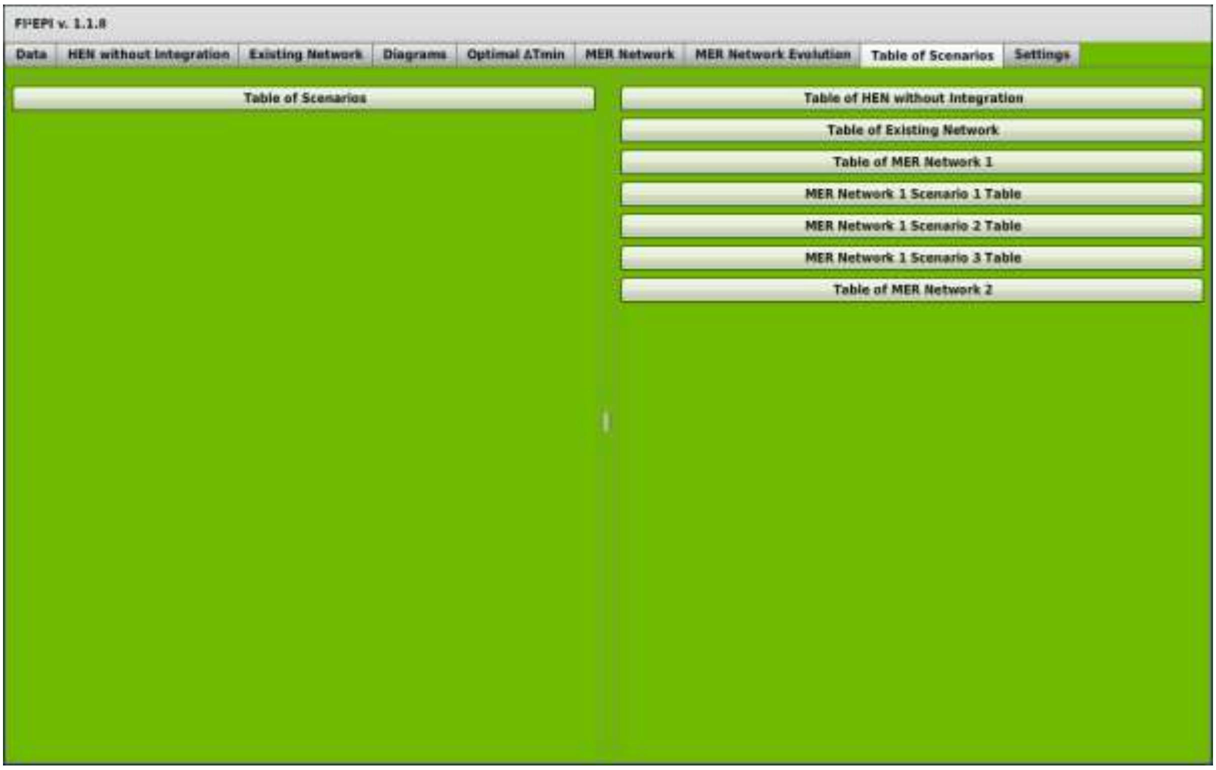



**Figure 85 - Table of Scenarios**

### Table of Scenarios window

In the *Table of Scenarios* window, the user obtain a summary table of the networks generated before: *HEN without Integration*, *Existing Network*, *MER Network* and the *Scenarios* related to the MER network evolution.

On the *Table of Scenarios* table, it is possible to compare the alternatives concerning the effective ΔTmin value of the network, number of HE's, total area, utilities' consumption, operating costs, capital costs and the total cost of each network.

**Table of Scenarios**

| Scenario | ΔTmin (°C) | HE's no. | Total Area (m²) | HU (kW) | CU (kW) | Operating Cost (€/year) | Capital Cost | Total Annual Cost (€/year) |
|---|---|---|---|---|---|---|---|---|
| HEN without Integration | 20 | 4 | 307 | 5700 | 5500 | 1005609.00 | 61750.88 | 1067359.88 |
| Existing HEN | 20 | 6 | 388 | 4100 | 3900 | 723161.00 | 81161.57 | 804322.57 |
| MER Network 1 | 20 | 7 | 769 | 1000 | 800 | 175918.00 | 144455.62 | 320373.62 |
| Scenario 1 MER Network 1 | 20 | 6 | 479 | 1620 | 1420 | 285366.60 | 95511.85 | 380878.45 |
| Scenario 2 MER Network 1 | 20 | 5 | 463 | 1620 | 1420 | 285366.60 | 89716.23 | 375082.83 |

**Figure 86 - Table of Scenarios table**

The ΔTmin value that appears in this table corresponds to the one used for all the networks constructed. The existence of scenarios obtained from the MER Network evolution, with ΔTmin lower to the minimum, appears every time the user allows violations thermodynamically feasible in the constricted scenarios.

The features of *HEN without integration* and *Existing Network* automatically appear in the summary table of scenarios, once these are complete.

On the *MER Network* tab, the MER Network only appears in the *Table of Scenarios* when said table is complete. The remaining *Scenarios* obtained from the MER Network evolution appear as they are being constructed on the *MER Network* Evolution tab.

#### *Table of HEN without Integration* window

In the *Table of HEN without integration* window, there is a summary of the *HEN without integration* scenario, obtained on the *HEN without integration* tab, which includes temperatures, utilities' consumption, features of each heat exchanger and other associated costs.

#### Table of HEN without Integration window

In this window, it is possible to visualise the detailed summary of *HEN without integration* scenario, obtained in the tab with the same name, with description of temperatures, utilities' consumption, features of each heat exchanger and other associated costs.

**Table of HEN without Integration**

| | Description | | Hot | | Cold | | Q | U | ΔTln | Calculated | Calculated | Hourly |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | (kW) | (kW/m²·°C) | (°C) | Area (m²) | Cost (€) | Cost (€/h) |
| UT1 | High Pressure Steam | HE1 | 250 | 250 | 50.0 | 210 | 3200 | 0.42 | 99.4 | 77.3 | 69077.11 | 65.31 |
| | | HE2 | 250 | 250 | 160 | 210 | 2500 | 0.42 | 61.7 | 97.3 | 83118.14 | 51.02 |
| UT2 | Cold Water | HE3 | 270 | 160 | 15.0 | 20.0 | 1980 | 0.33 | 192.8 | 30.8 | 36571.20 | 0.71 |
| | | HE4 | 220 | 60.0 | 15.0 | 20.0 | 3520 | 0.33 | 103.9 | 102 | 86137.50 | 1.27 |
| | | | | | | | | | | Total Cost: | 274903.95 | 118.31 |

**Figure 87 - Table of HEN without integration**

#### Table of Existing Network window

In the *Table of Existing Network* window, there is a summary of the *Existing Network* scenario, obtained on the *Existing Network* tab, which includes temperatures, utilities' consumption, features of each heat exchanger and other associated costs.

**Table of Existing Network**

| | Description | | Hot | | Cold | | Q | U | ΔTln | Calculated | Calculated | Hourly |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ti (°C) | Tf (°C) | Ti (°C) | Tf (°C) | (kW) | (kW/m²·°C) | (°C) | Area (m²) | Cost (€) | Cost (€/h) |
| UT1 | High Pressure Steam | HE5 | 250 | 250 | 86.0 | 210 | 2480 | 0.42 | 87.9 | 67.7 | 62409.16 | 50.61 |
| | | HE6 | 250 | 250 | 178 | 210 | 1620 | 0.42 | 54.6 | 71.2 | 64839.46 | 33.06 |
| UT2 | Cold Water | HE3 | 270 | 200 | 15.0 | 20.0 | 1260 | 0.33 | 215.9 | 17.5 | 27257.29 | 0.45 |
| | | HE4 | 180 | 60.0 | 15.0 | 20.0 | 2640 | 0.33 | 90.7 | 87.4 | 76153.28 | 0.95 |
| | | HE1 | 200 | 160 | 50.0 | 86.0 | 720 | 0.25 | 112 | 25.7 | 33001.91 | |
| | | HE2 | 220 | 180 | 160 | 178 | 880 | 0.25 | 29.8 | 118 | 97655.77 | |
| | | | | | | | | | | Total Cost: | 361316.87 | 85.08 |

**Figure 88 - Table of Existing Network**

### Table of MER network window

The *Table of MER Network* window shows a summary of the *MER Network scenario*, obtained on the *MER Network* tab, which includes temperatures, utilities' consumption, features of each heat exchanger and associated costs.

**Table of MER Network 1**

| | Description | | Hot Ti (°C) | Hot Tf (°C) | Cold Ti (°C) | Cold Tf (°C) | Q (kW) | U (kW/m²·°C) | ΔTln (°C) | Calculated Area (m²) | Calculated Cost (€) | Hourly Cost (€/h) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UT1 | High Pressure Steam | HE1 | 250 | 250 | 190 | 210 | 1000 | 0.42 | 49.3 | 48.7 | 49059.07 | 20.41 |
| UT2 | Cold Water | HE6 | 180 | 160 | 15.0 | 20.0 | 360 | 0.33 | 152.4 | 7.09 | 19961.38 | 0.13 |
| | | HE7 | 80.0 | 60.0 | 15.0 | 20.0 | 440 | 0.33 | 52.1 | 25.3 | 32721.22 | 0.16 |
| | | HE2 | 270 | 236 | 178 | 190 | 620 | 0.25 | 68.4 | 36.3 | 40385.08 | |
| | | HE3 | 220 | 180 | 160 | 178 | 880 | 0.25 | 29.8 | 118 | 97655.77 | |
| | | HE4 | 236 | 180 | 160 | 210 | 1000 | 0.25 | 22.7 | 176 | 138541.72 | |
| | | HE5 | 180 | 80.0 | 50.0 | 160 | 2200 | 0.25 | 24.7 | 357 | 264766.51 | |
| | | | | | | | | | | Total Cost: | 643090.74 | 20.70 |

**Figure 89 - Table of MER Network 1**

### MER Network Scenario 1, 2, 3… window

In the MER Network Scenario 1, 2, 3… windows, a summary of the each Scenario, obtained in the corresponding Scenario tab, is given, including temperatures, utilities' consumption, and features of each heat exchanger and associated costs.

**MER Network 1 Scenario 1 Table**

| | Description | | Hot Ti (°C) | Hot Tf (°C) | Cold Ti (°C) | Cold Tf (°C) | Q (kW) | U (kW/m²·°C) | ΔTln (°C) | Calculated Area (m²) | Calculated Cost (€) | Hourly Cost (€/h) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UT1 | High Pressure Steam | HE1 | 250 | 250 | 178 | 210 | 1620 | 0.42 | 54.6 | 71.2 | 64839.46 | 33.06 |
| UT2 | Cold Water | HE6 | 180 | 160 | 15.0 | 20.0 | 360 | 0.33 | 152.4 | 7.09 | 19961.38 | 0.13 |
| | | HE7 | 108 | 60.0 | 15.0 | 20.0 | 1060 | 0.33 | 64.2 | 49.5 | 49679.31 | 0.38 |
| | | HE3 | 220 | 180 | 160 | 178 | 880 | 0.25 | 29.8 | 118 | 97655.77 | |
| | | HE4 | 270 | 180 | 129 | 210 | 1620 | 0.25 | 55.4 | 117 | 96909.54 | |
| | | HE5 | 180 | 108 | 50.0 | 129 | 1580 | 0.25 | 54.5 | 116 | 96156.32 | |
| | | | | | | | | | | Total Cost: | 425201.77 | 33.57 |

**Figure 90 - MER Network 1 Scenario 1 Table 1**

## 13. Settings tab

Using the Settings tab, the user is allowed to choose the units for each variable that appears/are used in the tables, graphs and diagrams. Fi²EPI's default units are set as shown below:

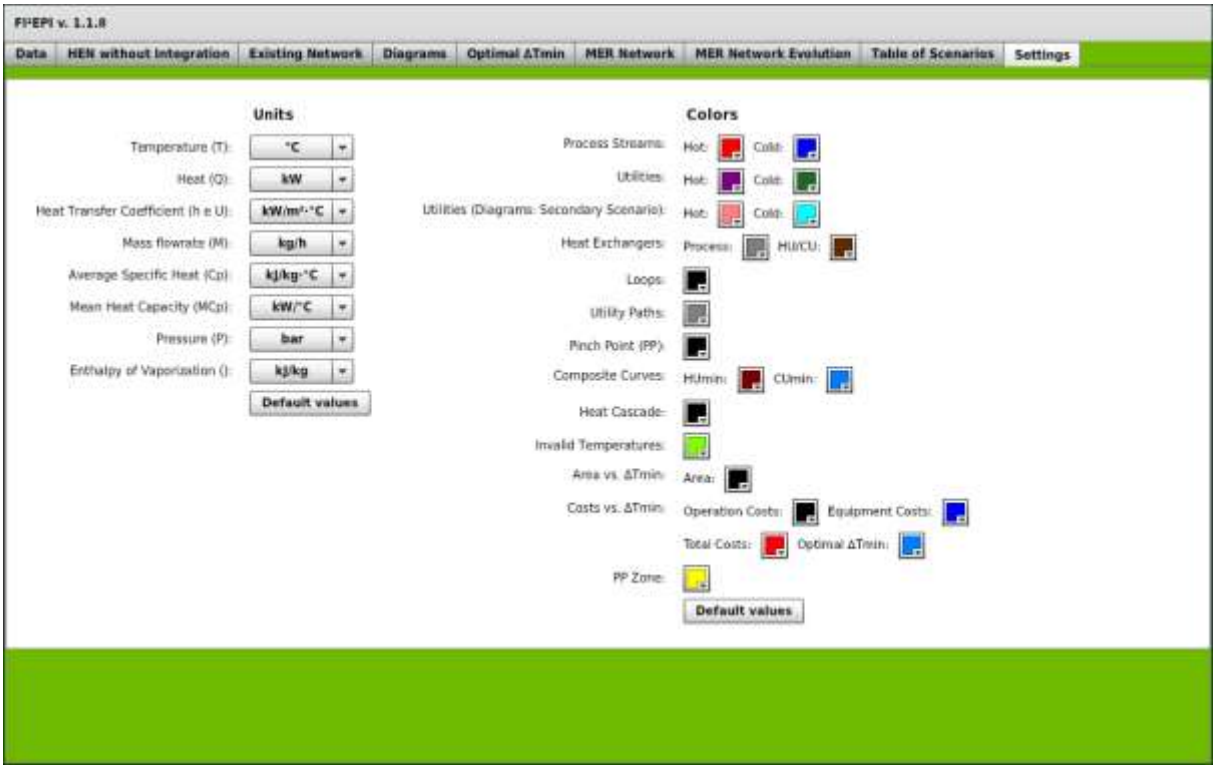



**Figure 91 - Settings**

Whenever the units in this tab are changed, Fi²EPI automatically converts the variables chosen on the *Data* tab into the selected units, in all windows of all tabs.

This tab also allows the user to change the colours of the tables, graphs, diagrams and streams.