



Heat Exchanger Design Network

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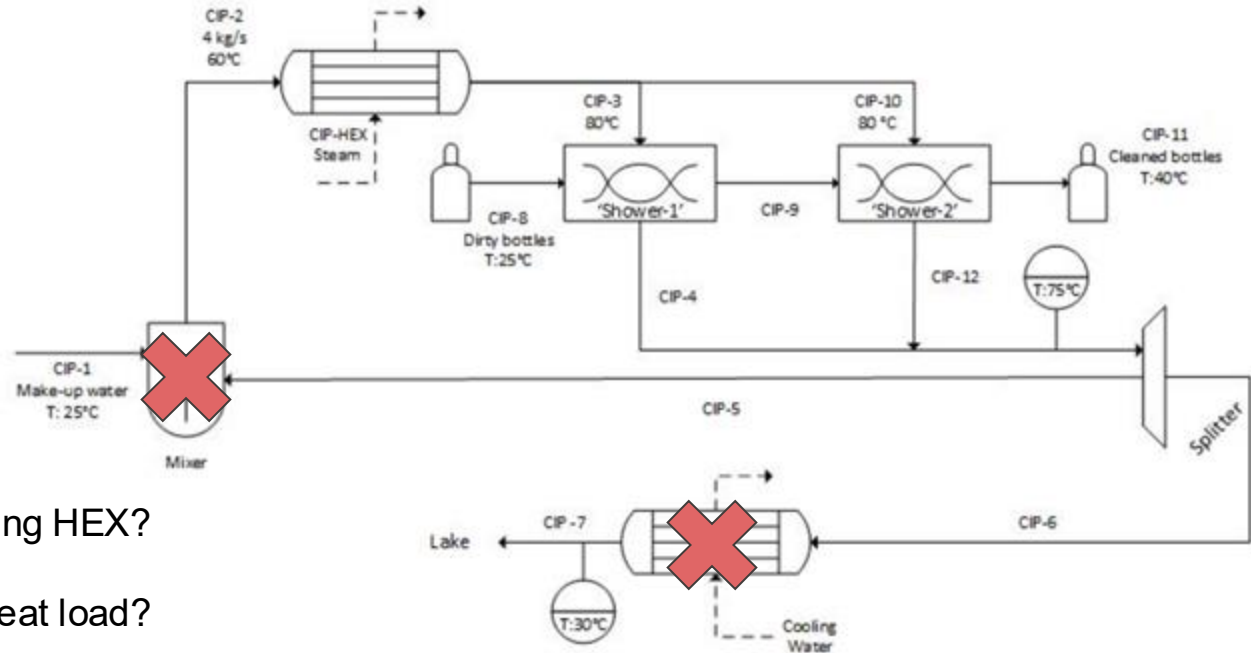
Sion – 13.10.2025

Identify penalizing HEX

Let's assume the pinch point is at 50°C



Penalizing HEX



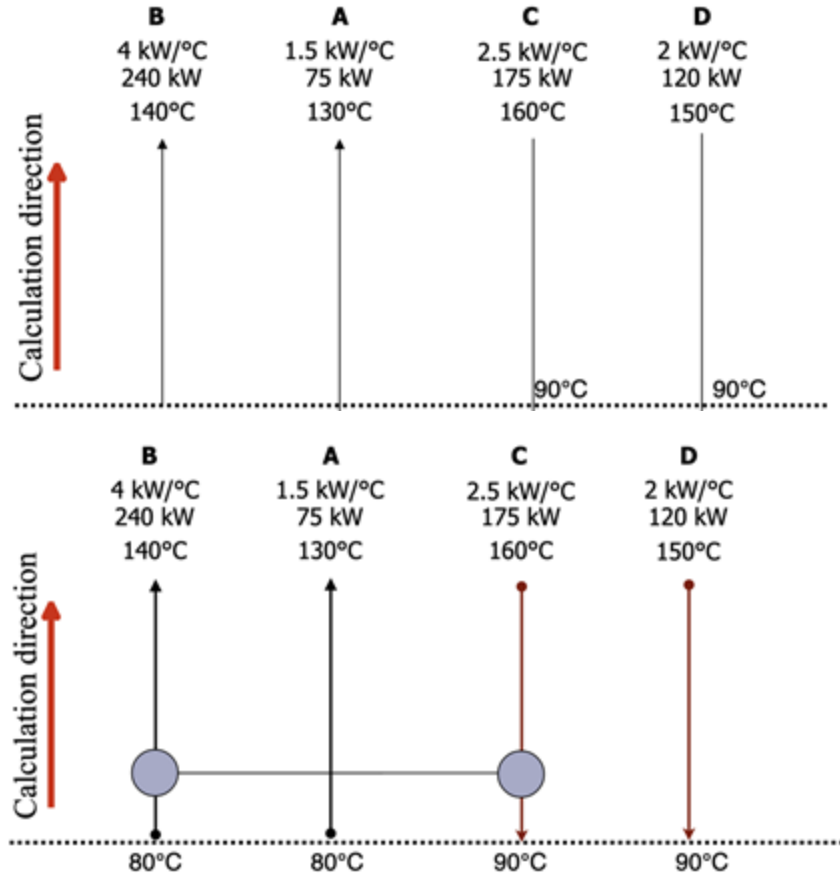
Which types of penalizing HEX?

How much penalized heat load?

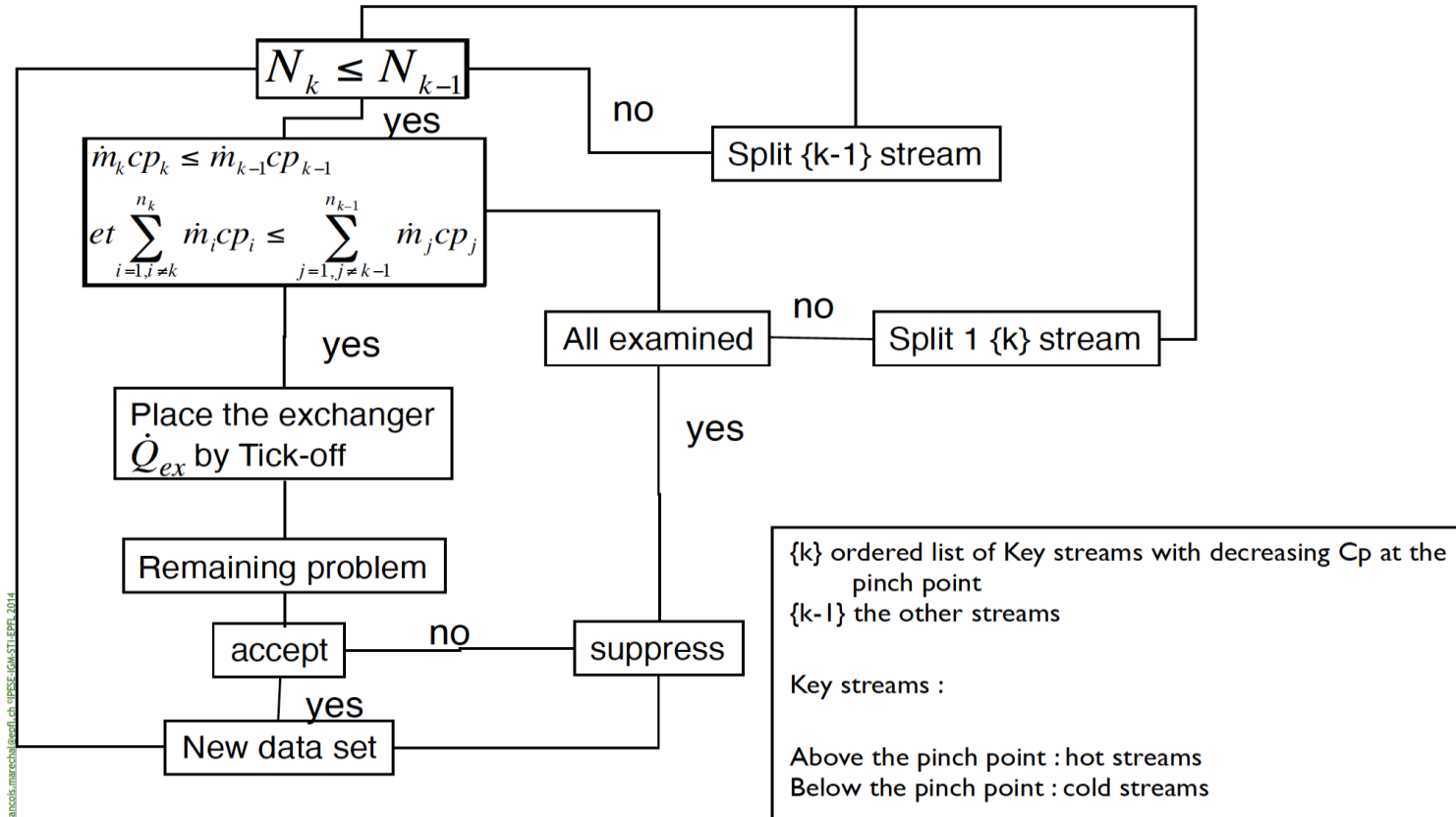
How it affects the energy bill?

Build the HEN representation

- Draw the grid representation for the cleaning in place process streams. Use corrected temperatures.
- Fix the non-penalizing heat exchanger.
- Finalize the design by applying the pinch design method.



HEN synthesis algorithm

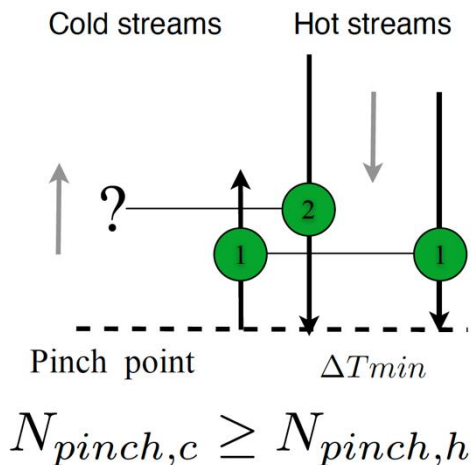


Feasibility rules for connection

For pinch heat exchangers – The temperature difference is ΔT_{min} on one side.

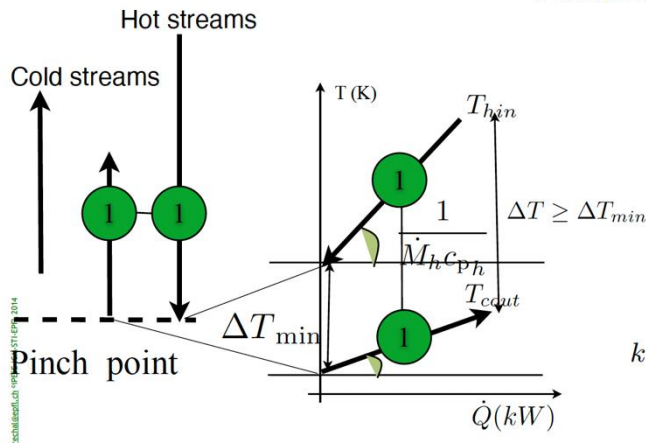
Case 1 – Above the pinch point

No. of stream rule



Feasibility rules

Connexion feasibility between c and h



$$\dot{M}c_{p,h} \leq \dot{M}c_{p,c}$$

AND

$$\sum_{k=1, k \neq h}^{n_k} \dot{M}c_{p,k} \leq \sum_{j=1, j \neq c}^{n_{k-1}} \dot{M}c_{p,j}$$

Tick-off rule and Remaining problem analysis

After deciding the two streams for placing a HEX based on the feasibility rules, the heat load of the HEX is decided by the tick-off rule

$$\dot{Q} = \min(\dot{M}_c c_{p_c} (T_{c,out} - (T_p^* - \Delta T_{\min}/2)), \dot{M}_h c_{p_h} (T_{h,in} - (T_p^* + \Delta T_{\min}/2)))$$

$$\Rightarrow T_{h,in,ex}, T_{c,out,ex}$$

$$T_{h,in,ex} = T_p^* + \Delta T_{\min}/2 + \frac{\dot{Q}}{\dot{M}_h c_{p_h}} \quad T_{c,out,ex} = T_p^* - \Delta T_{\min}/2 + \frac{\dot{Q}}{\dot{M}_c c_{p_c}}$$

One of the two flows will be ticked off (meaning, the other stream supplies all of its heating or cooling needs)

After placing the heat exchanger and calculating the new temperatures of the hot and cold streams, the **Remaining problem analysis** calculates the Minimum energy requirement with and without the heat exchanger. If MER does not change, the heat exchanger is well placed.

Above the pinch

Calculation starts from the pinch and goes to higher temperatures

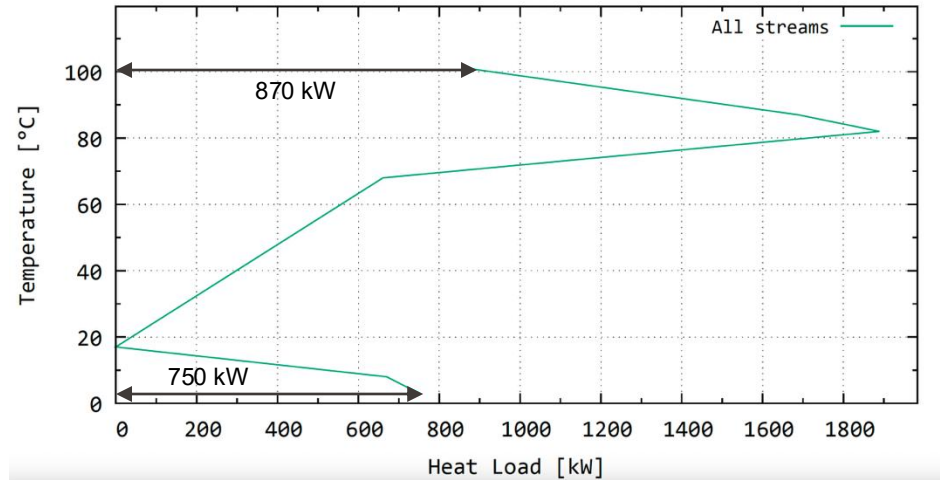
Both side !!!

We calculate the inlet conditions of the hot stream and the outlet conditions of the cold stream

if $\dot{Q}^{+r} = \dot{Q}^{+0}$
 \Rightarrow Exchanger is well placed

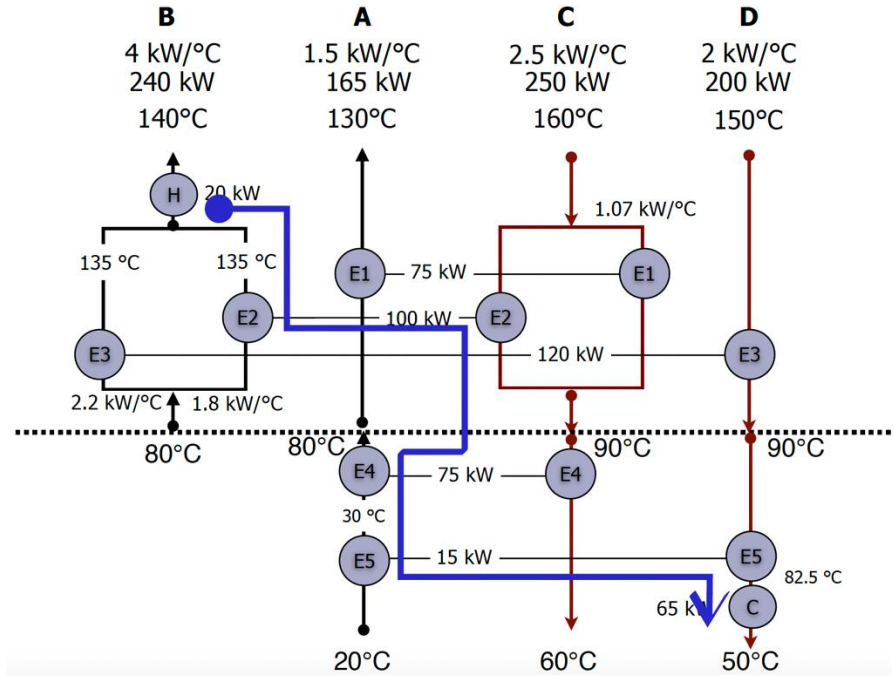
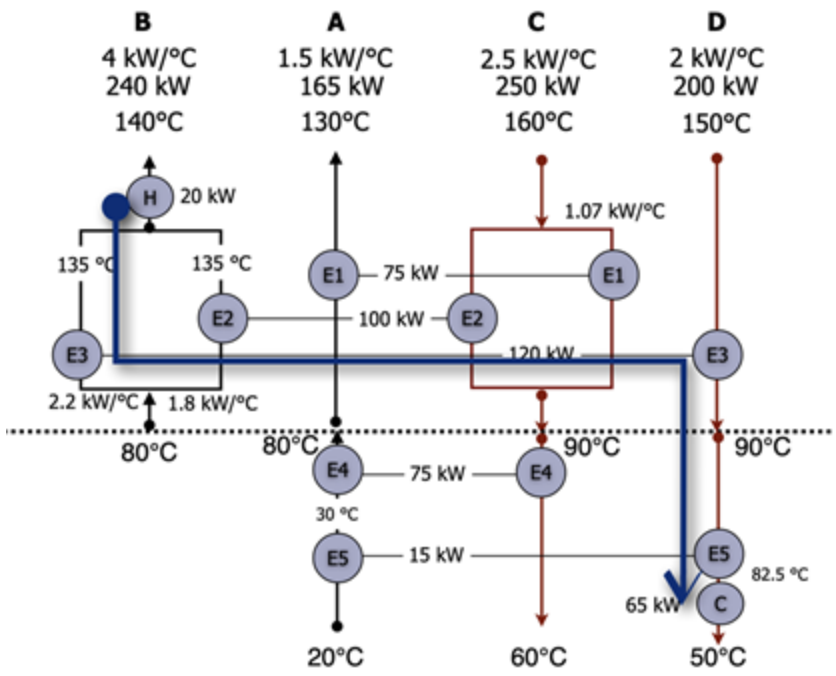
Brewery example

| Name | Description | T_{in} (°C) | T_{out} (°C) | Q (kW) | MC _p (kW/°C) |
|------|-----------------|---------------|----------------|--------|-------------------------|
| A | Wort cooling | 103 | 10 | 5435 | 58 |
| B | Cold bath | 70 | 5 | 4854 | 74.4 |
| C | Water filter | 15 | 80 | 1609 | 24.8 |
| D | Pasteurization | 15 | 80 | 4854 | 74.4 |
| E | Water bath | 15 | 85 | 1287 | 18.3 |
| F | CIP | 15 | 80 | 1841 | 28.4 |
| G | Beer preheating | 1 | 15 | 822 | 58 |

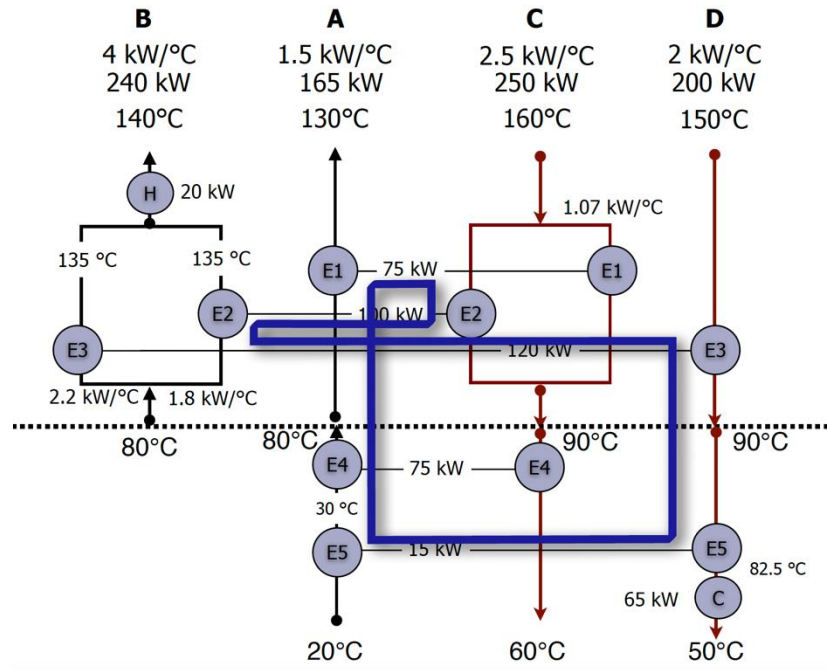
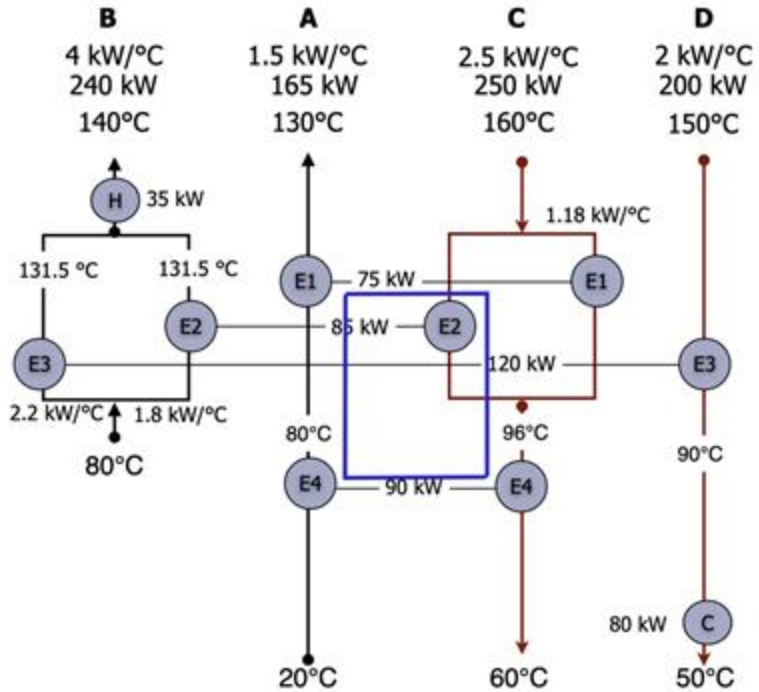


We have the heat exchange network design for the selected streams of the brewery. The minimum energy requirement (MER) as computed above is 870 and 750 kW of hot and cold utility respectively. The total cost of the system is computed by annualising the cost of the proposed six heat exchangers (CAPEX) and the operating cost for satisfying the MER (OPEX).

Path and loop following methods



Path and loop following methods



Path and loop following methods

| | Invest [CHF] | CAPEX [CHF/year] | OPEX [CHF/year] | Total [CHF/year] | Nb Ex. |
|---|-----------------|---------------------|--------------------|---------------------|----------|
| 0 | 173905 | 20340 | 2352 | 22692 | 7 |
| 1 | 189859 | 22206 | 2352 | 24558 | 6 |
| 2 | 190001 | 22222 | 2352 | 24574 | 6 |
| 3 | 145847 | 17058 | 4118 | 21176 | 6 |
| 4 | 133491 | 15613 | 4118 | 19731 | 6 |
| 5 | 147924 | 17301 | 4118 | 21419 | 5 |
| 6 | 99723 | 11664 | 16471 | 28135 | 6 |

Expected final result format of the Heat exchanger network design in the report

TODO Summary

- Based on the pinch point temperature, **find the penalizing heat exchangers in the CIP process**. Don't forget to mention the type of penalizing HEX. **Calculate the penalized heat loads and the associated operating costs**.
- Draw the grid representation of the heat exchanger network for the **cleaning in place**. Since your boss doesn't want to change all the layout of the factory, fix the nonpenalizing heat exchanger. Ideally, you won't change them.
- Apply the pinch design method to design the HEN. Use the corrected temperature for the HEN design and the real ones to calculate the area of the HEXs
- Once you have a design, improve it using the path and loop following methods
- **Compare the costs, the total heat exchange area, and the total heat being exchanged** for your different layouts (initial layout, new layout, optimized new layout)