Heat exchanger network design

Heat exchanger network representation for maximum heat recovery

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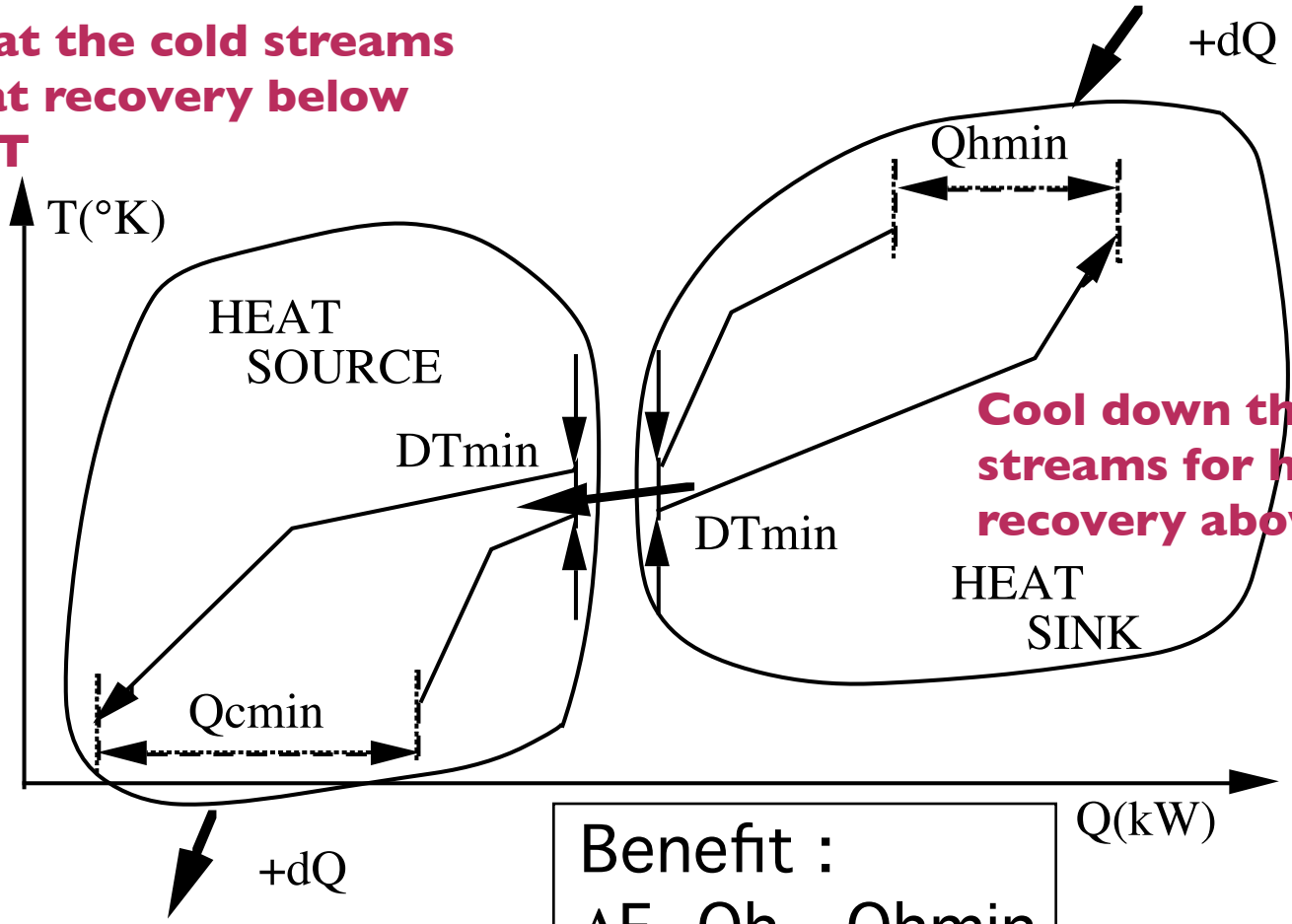
Conclusions of previous steps

- DTmin optimum
- Maximum heat recovery target
  - Utility heat load (hot, cold and refrigeration)
- Pinch point location
- Minimum number of heat exchangers
- Overall DTmin
- Non penalising heat exchangers
  - reduces the list of hot and cold streams to be considered

What is the heat exchanger network ?

The more in - the more out

Preheat the cold streams by heat recovery below pinch T



Cool down the hot streams for heat recovery above pinch T

Benefit :

$\Delta E = Qh - Qhmin$

$\Delta E = Qc - Qcmin$

QH-QC = Constant !

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Minimum number of units

Pinch point = two independent sub-systems

Number of Independent sub-systems above the pinch point

Number of Independent sub-systems below the pinch point

$$U_{\min,MER} = (N_{above} - 1 - S_{above}) + (N_{below} - 1 - S_{below})$$

Number of streams above the pinch point

Number of streams below the pinch point

$$U_{\min,MER} = (N_{total} + N_{utility} - 1) + (N_{pinch} - 1) - (S_{above} + S_{below})$$

Number of Independent sub-systems below and above the pinch point

Total number of streams, including the utilities

Number of streams crossing the pinch point

Heat exchangers network synthesis

Find a heat exchangers network that satisfies:
- *MER*
- *Minimum number of units*
- *Minimum investment*
- *Other criteria*

- Which hot stream exchanges with which cold stream ?

- What is the heat exchanged ?

- What is the structure : serial or //, ...

Above pinch point

Drive hot streams to the pinch point or target temperature without cold utility

Below pinch point

Drive the cold streams to the pinch point or target temperature without hot utility

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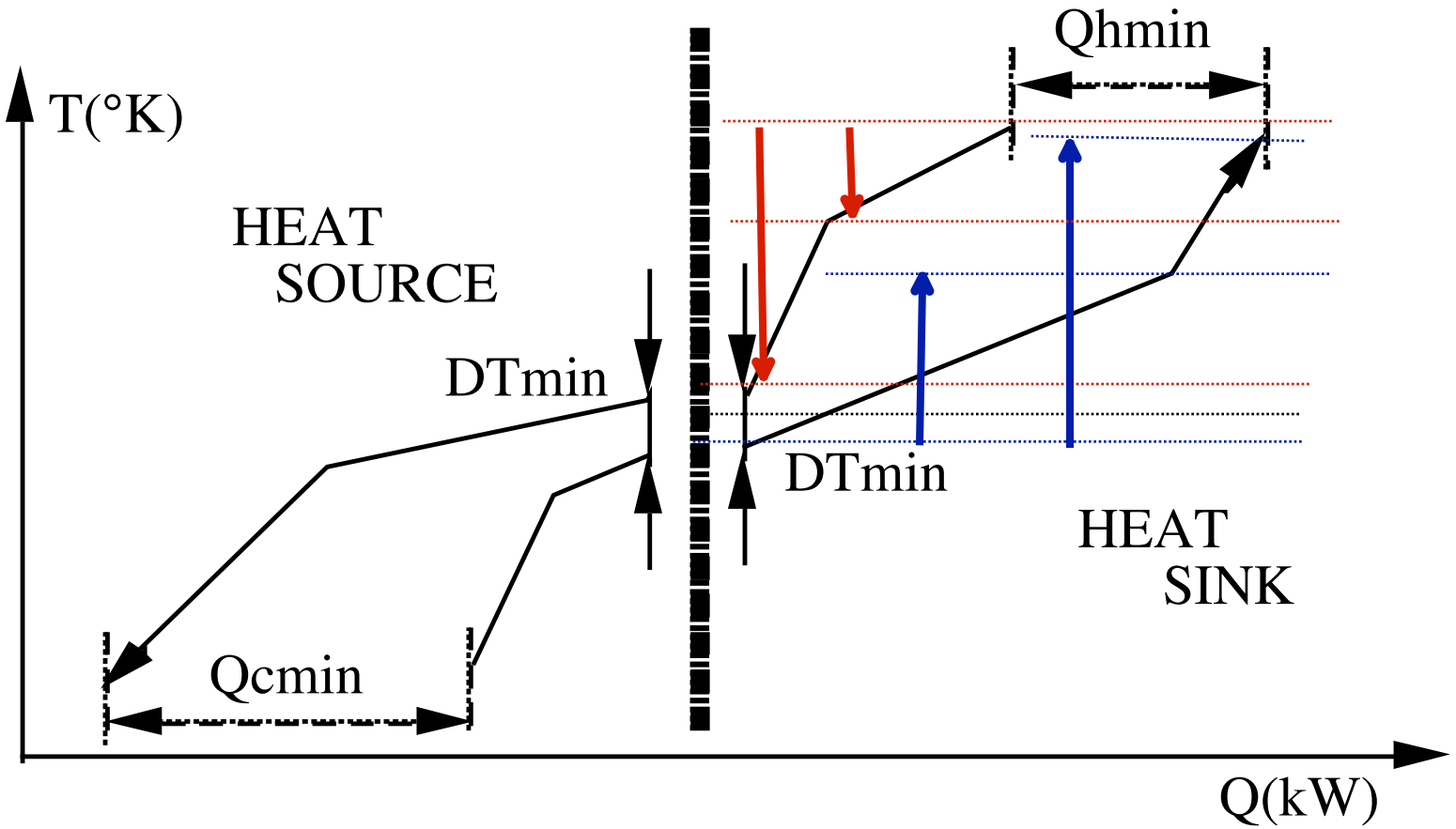
Pinch point

Two independent sub-systems



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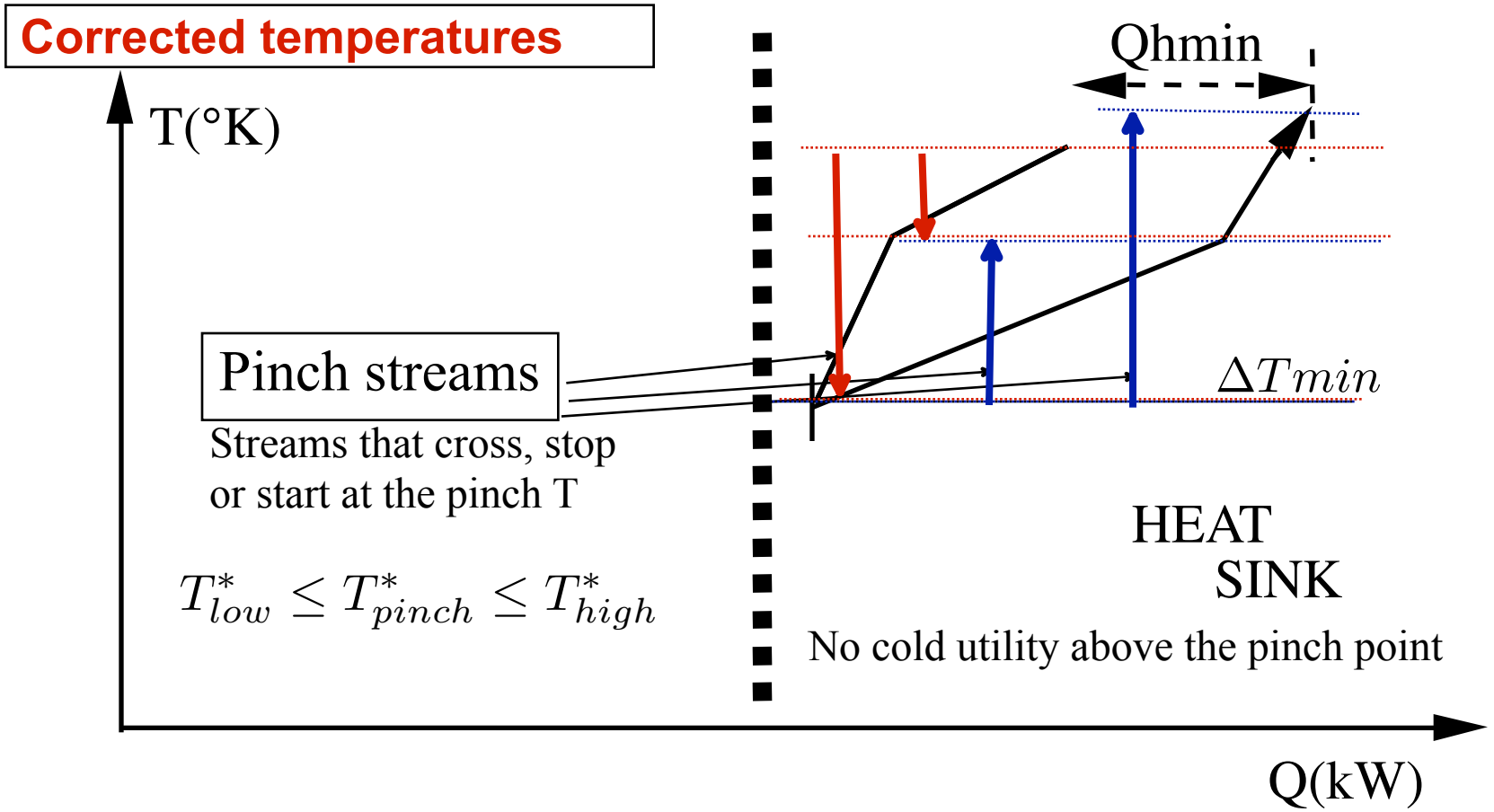
Above the Pinch point

The goal is to cool down hot streams to the pinch temperature or the target temperature without additional utility streams



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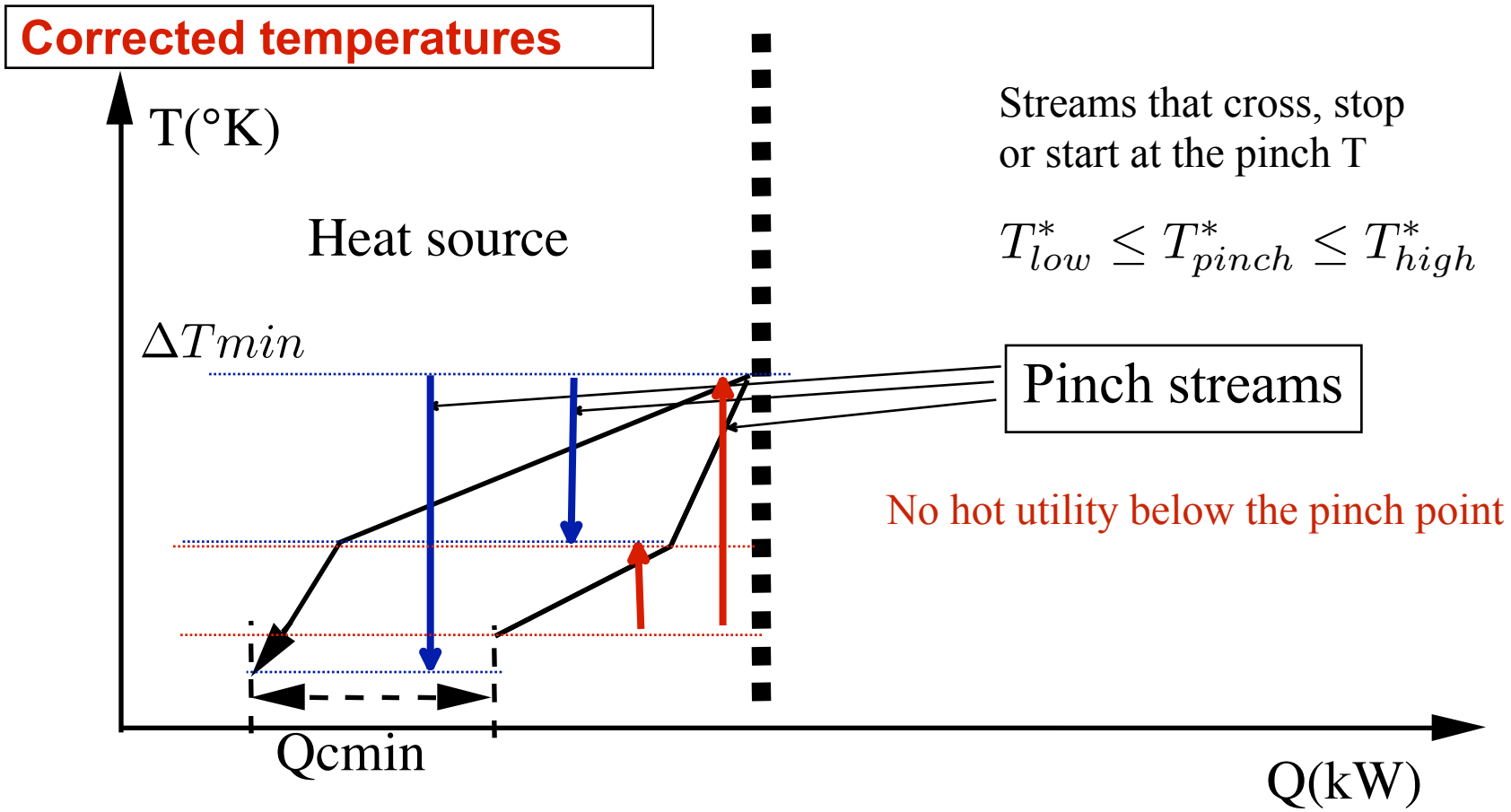
below the Pinch point

The goal is to heat up cold streams to the pinch temperature or the target without additional hot utility



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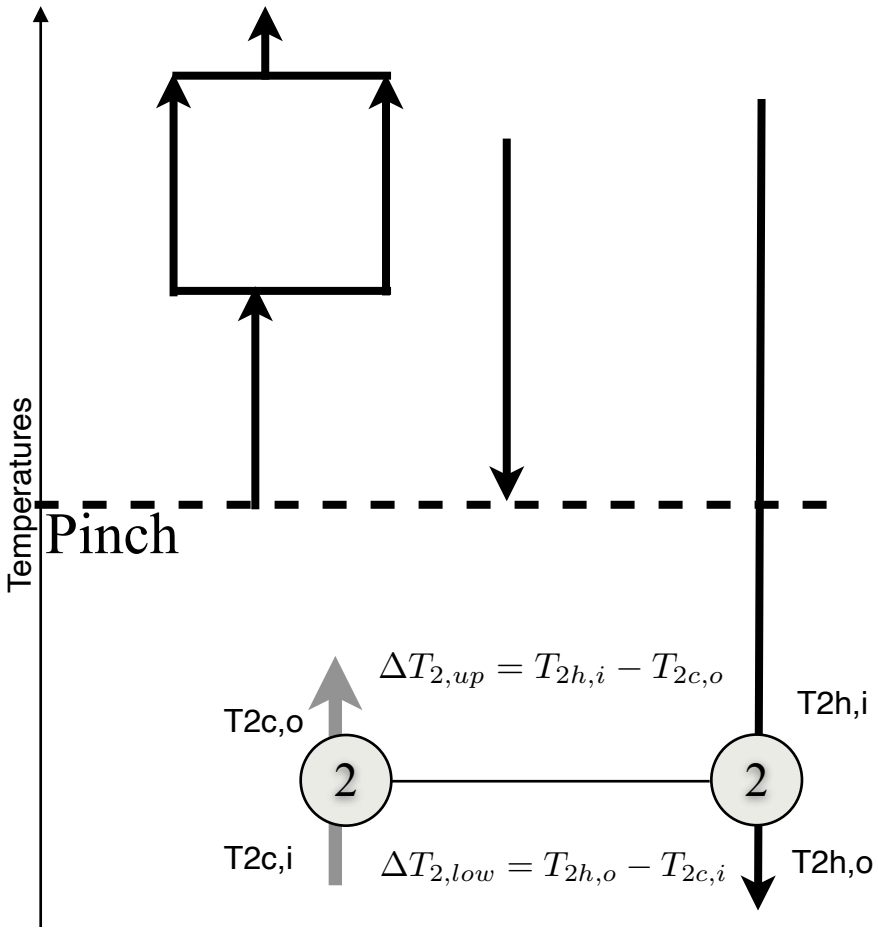
Grid representation of HEN

Assuming counter-current heat exchangers



$$\dot{Q}_2 = \dot{M}_{2h} cp_{2h} (T_{2h,i} - T_{2h,o})$$

$$\dot{Q}_2 = \dot{M}_{2c} cp_{2c} (T_{2c,o} - T_{2c,i})$$

$$\Delta T_{lm,2} = \frac{\Delta T_{2,up} - \Delta T_{2,low}}{ln(\frac{\Delta T_{2,up}}{\Delta T_{2,low}})}$$

$$A_2 = \frac{\dot{Q}_2 \cdot (\frac{1}{\alpha_{2h}} + \frac{1}{\alpha_{2c}})}{\Delta T_{lm,2}}$$

Streams are vertical lines with a clear location of the pinch point (do not use real temperature scales as streams might have infinite cp when phase change occur).
Pinch streams are streams that are start from or cross the pinch
Heat exchangers are represented by horizontal lines with 2 circles identifying the connected streams. Counter current heat exchangers have therefore the hot end at the top and the cold end at the bottom, logmean temperature difference are easy to identify

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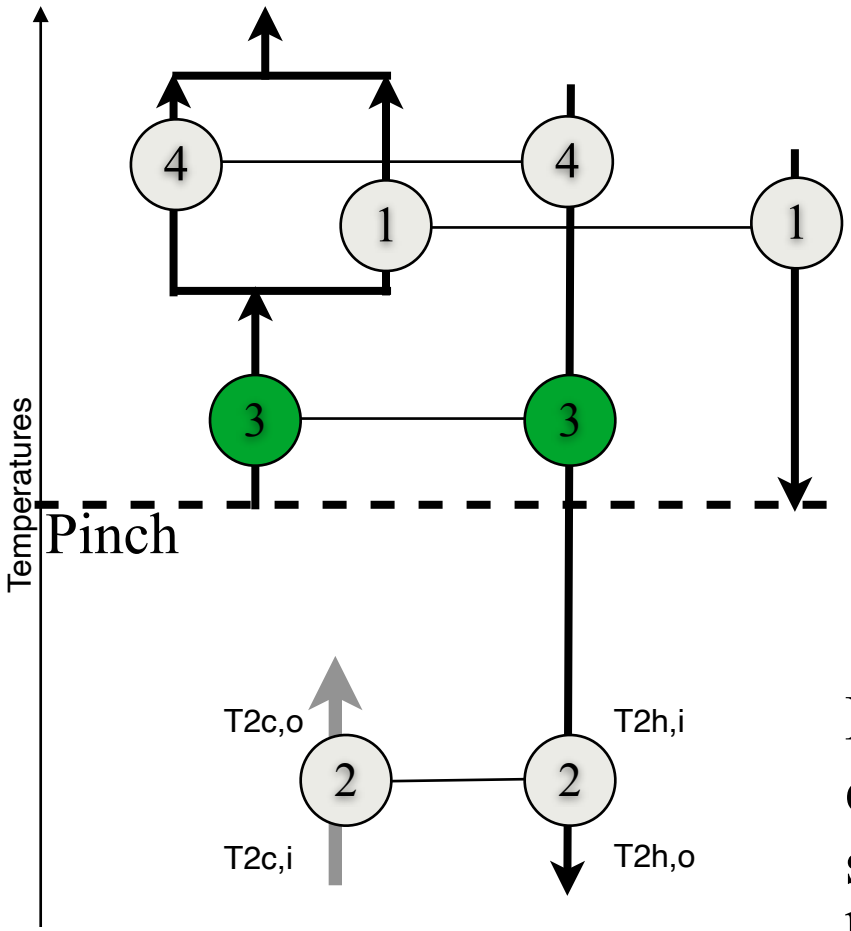
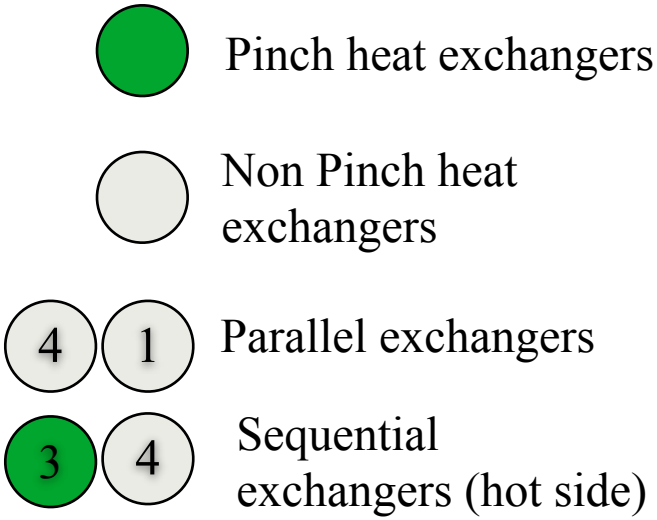
Grid representation of HEN

Streams with inlet and outlet temperatures





Pinch heat exchangers are heat exchanger for which one side (both streams) is at the pinch point, i.e. have $\Delta Tmin$ on one side the counter current heat exchanger

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Conclusion HEN representations

- **The grid representation of heat exchangers in a heat exchanger network**
  - vertical lines : streams from inlet conditions to target
  - horizontal lines : counter current heat exchangers
  - Parallel or serial heat exchanges
    - Parallel :
      - split : mass flow fraction
      - mix : recalculate temperatures from flows
  - Pinch sections
    - **Pinch streams** : one side at the pinch temperature (stream is splitted into 2 parts : above and below the pinch)
    - **Pinch heat exchangers** : both streams are at the pinch (hot AND cold streams are pinch streams)
    - Calculation direction : from the pinch
      - Above the pinch : increasing temperature
        - » **Hot streams : calculate inlet conditions**
        - » **Cold streams calculate outlet conditions**
      - below the pinch : decreasing temperature
        - » **Hot streams : calculate outlet conditions**
        - » **Cold streams calculate inlet conditions**

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