

CHE 551 Advanced Topics In Chemical Engineering

**Energy
Optimization Using
Pinch Analysis**

Lecture 4

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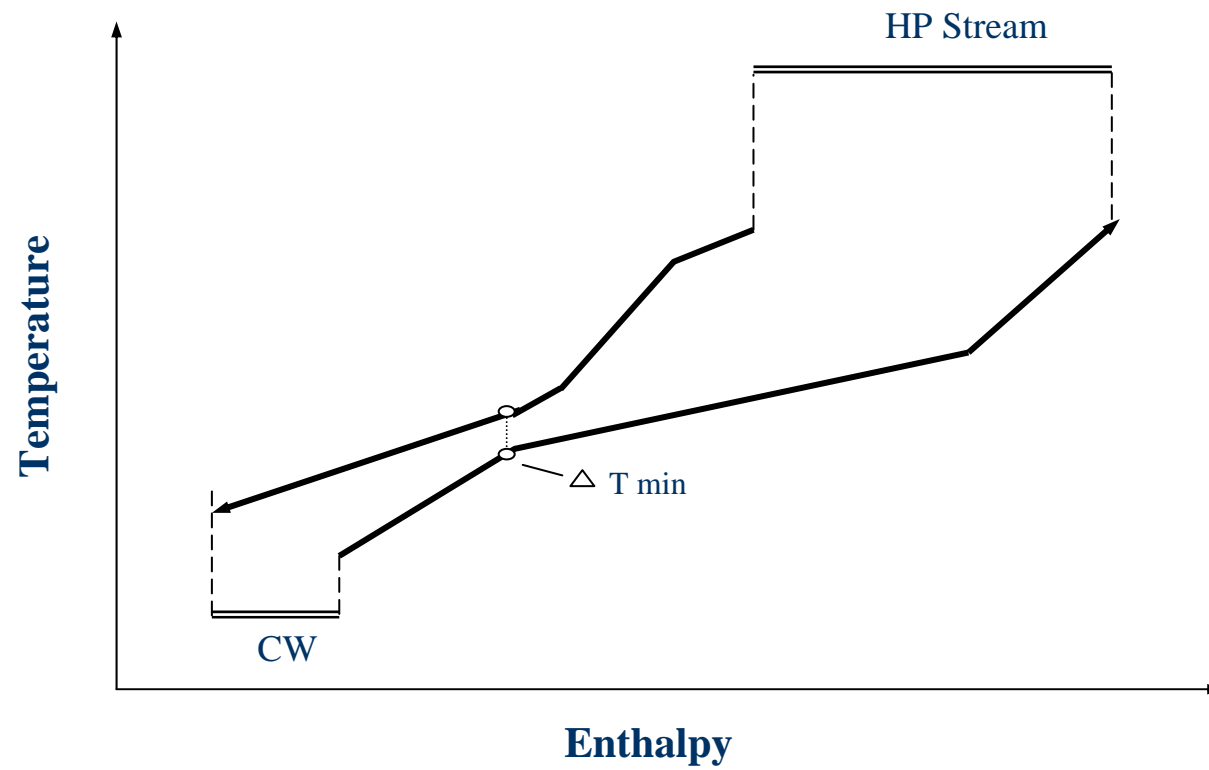


Multiple Utilities Targeting

- The composite curves provide the overall energy targets without any reference as to the quantity of energy that must be supplied by the various utility levels.
- Such information is particularly useful when a single hot and cold utility is available for the process.
- In many industrial applications, the energy requirement for a process can be supplied by several different utilities such as cooling water, refrigeration and steam.

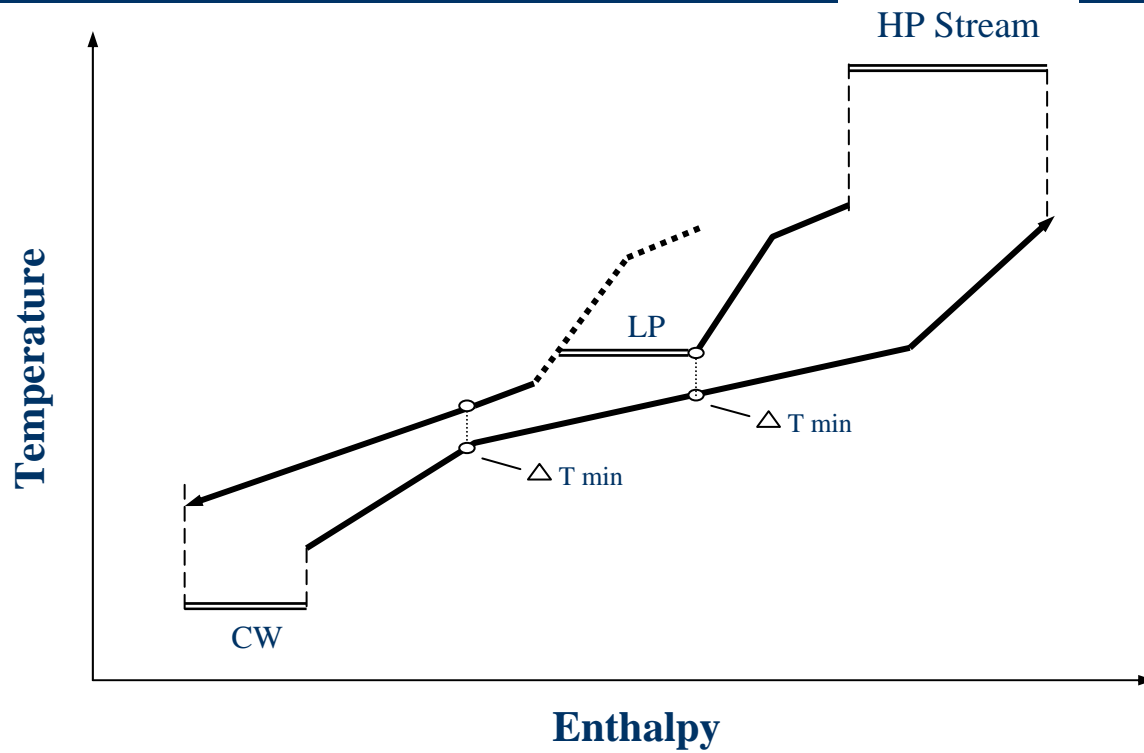
The objective is to maximize the use of the less expensive utilities and minimize the use of the more expensive utilities.

COMPOSITE CURVES FOR MULTIPLE UTILITIES TARGETING



(a)

COMPOSITE CURVES FOR MULTIPLE UTILITIES TARGETING



(b)

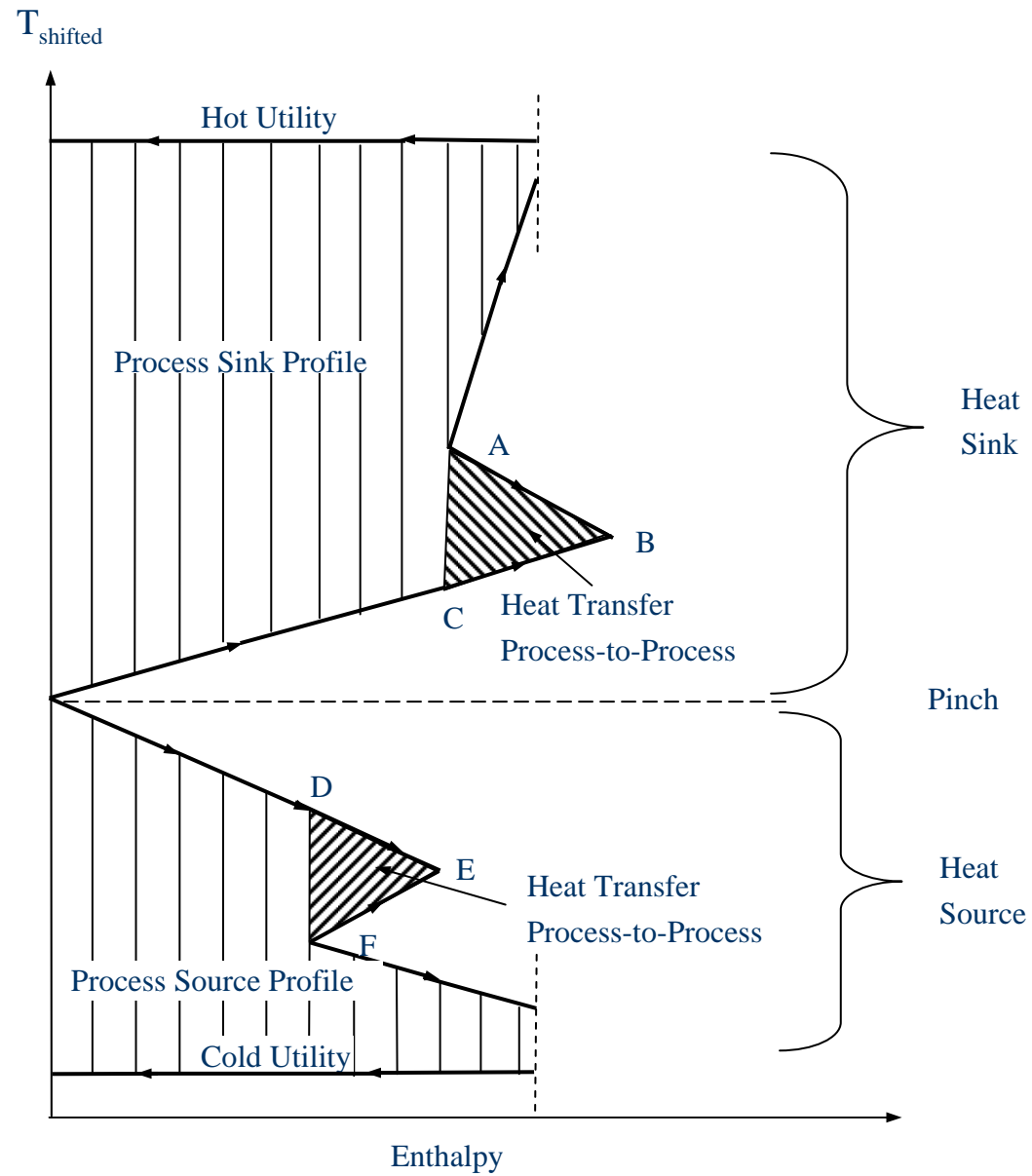
Grand Composite Curve (GCC)

- The GCC is a plot of interval temperatures against corresponding heat flow quantities. The temperatures of the hot and cold process streams are divided into interval temperatures according to the supply and target temperatures of the hot and cold streams, respectively.
- The GCC plot depends on the process stream conditions as well as the minimum temperature approach.

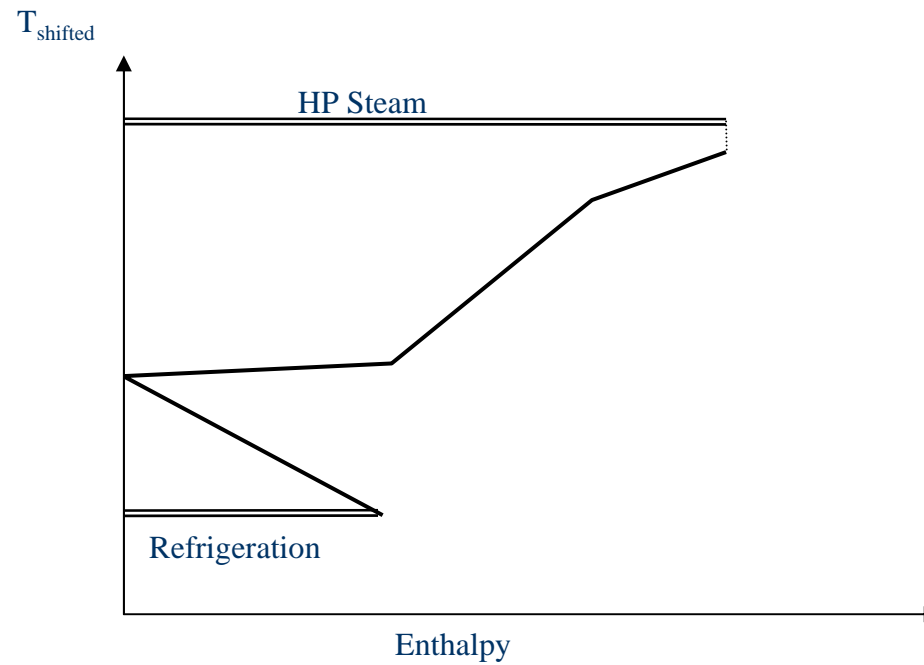
Grand Composite Curve (GCC)

- The GCC approach is based on the same stream data as used in the composite curves but is a more appropriate aid for representing the interface between the process and utility system.
- The grand composite curve provides the same overall energy target as the composite curves.

Grand Composite Curve (GCC)

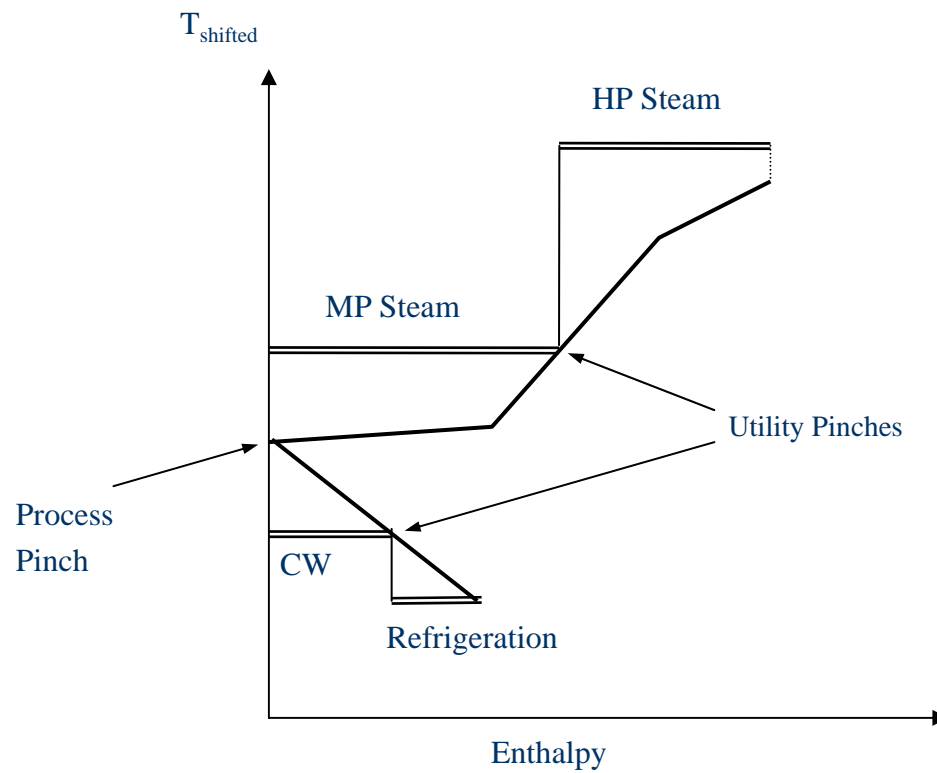


Grand Composite Curve (GCC) For Multiple Utilities Targeting



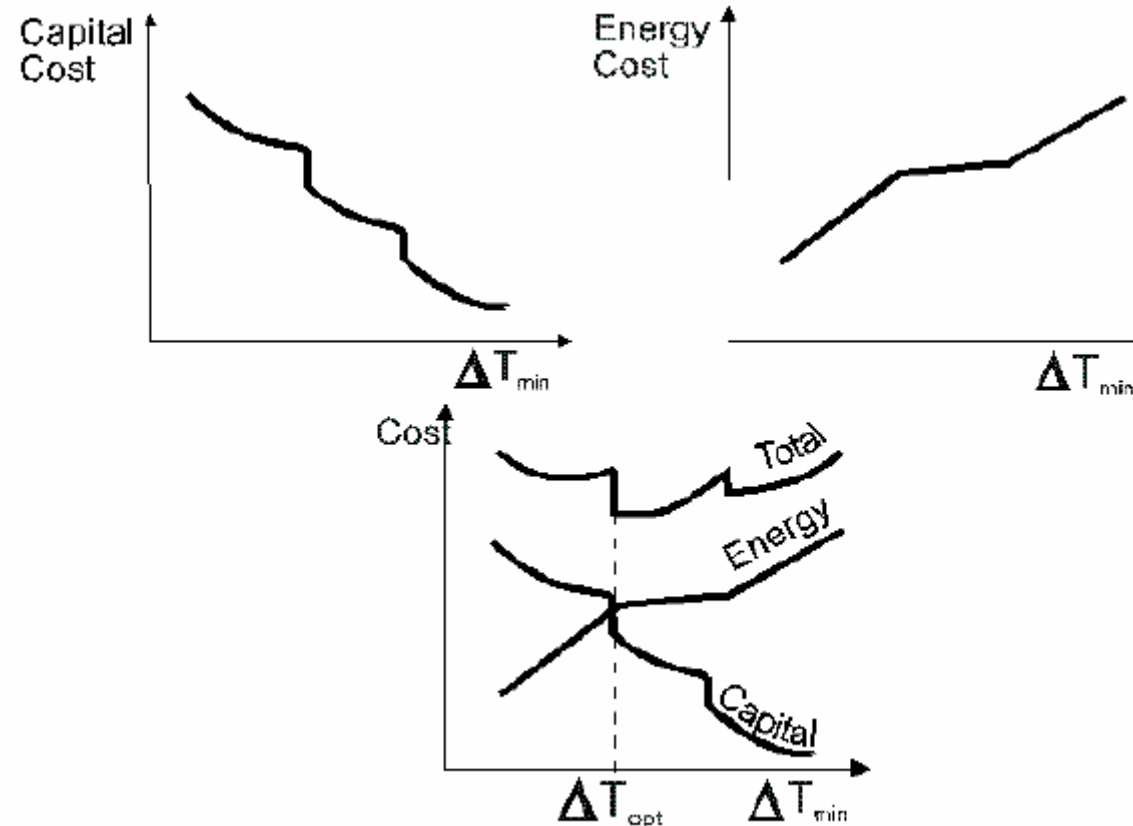
(a)

Grand Composite Curve (GCC) For Multiple Utilities Targeting

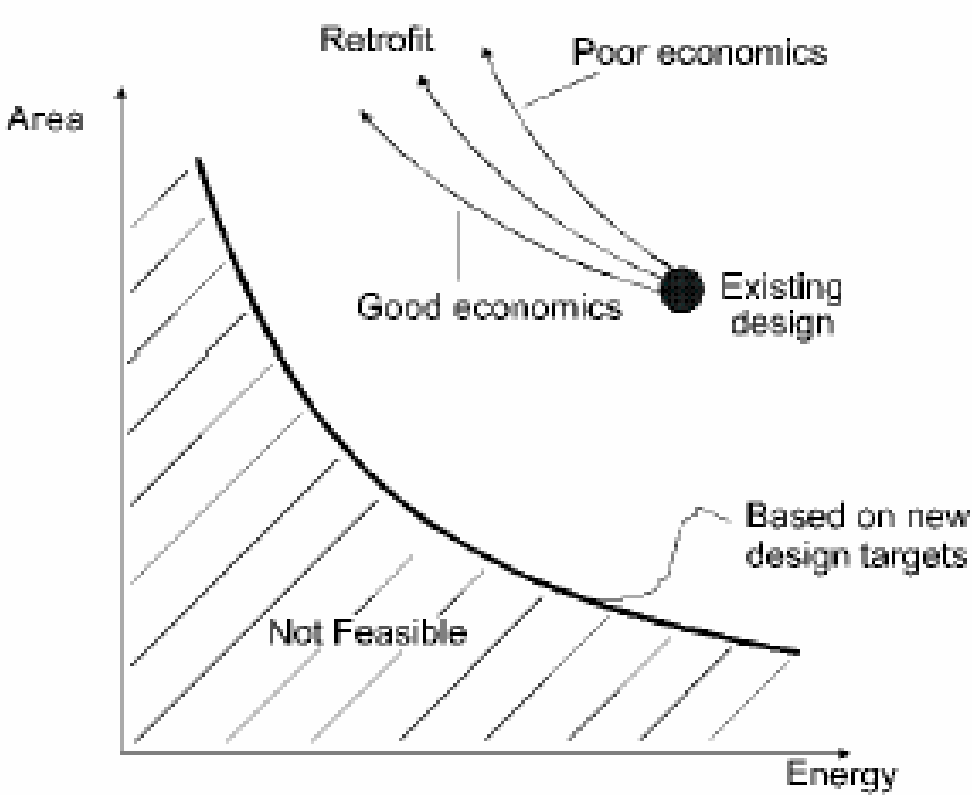


(b)

The Trade-off between Energy and Capital Costs Gives the Optimum ΔT_{min} for Minimum Cost in New Designs



Capital Energy Trade off for Retrofit Applications



Number of Heat Exchange Units

- Euler's General Network Theorem is applied to the heat exchanger network design, the number of heat exchange units can be determined from

$$U = N + L - S$$

where

U = number of heat exchange units (including heaters and coolers),

N = number of streams (including utilities),

L = number of independent loops, and

S = number of separate components.

Minimum Number of Heat Exchange Units

- The final network design should be achieved with a minimum number of units to reduce the capital cost.
- To minimize the number of units, the number of loops should be zero. The most appropriate assumption for the number of separate components, N , is one. This leads to the targeting equation

$$U_{min} = N - 1$$

Minimum Number of Heat Exchange Units

- If the process exhibits a pinch, the above equation must be applied to each side of the pinch and then added as shown below:

$$U_{min} = \left(N_{Above\ the\ pinch} - 1 \right) + \left(N_{Below\ the\ pinch} - 1 \right)$$

Heat Exchanger Area Targets

$$A_{min} = \sum_{i=1}^{Interval} \frac{1}{\Delta T_{LM_i}} \left(\sum_{j=1}^{streams} \frac{q_j}{h_j} \right)$$

where

q_j = heat exchanged by stream j in interval i

h_i = heat transfer coefficient of stream j in interval i

ΔT_{LM_i} = log mean temperature difference in interval i