

CHE 551 Advanced Topics In Chemical Engineering

**Energy  
Optimization Using  
Pinch Analysis**

**Lecture 3**

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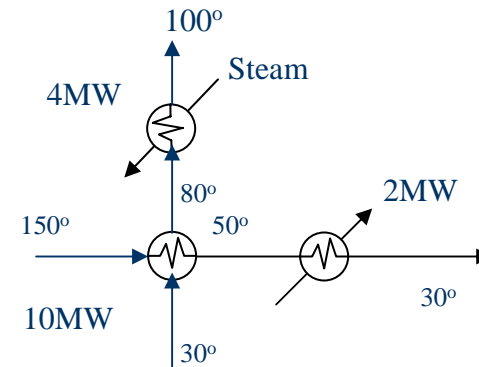
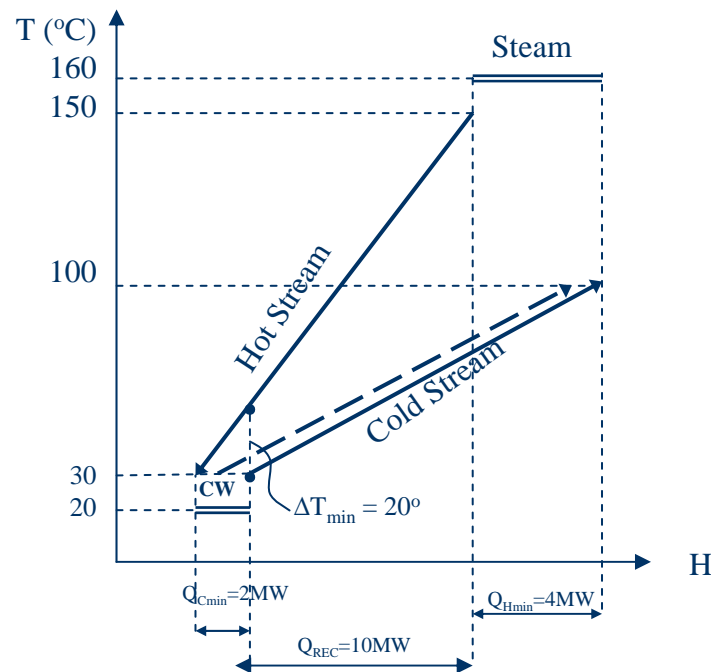
# Two Stream Heat Recovery Problem

Stream	Type	Supply temp. $T_S$ (°C)	Target temp. $T_T$ (°C)	$\Delta H$ (MW)
1	Cold	30	100	14
2	Hot	150	30	-12

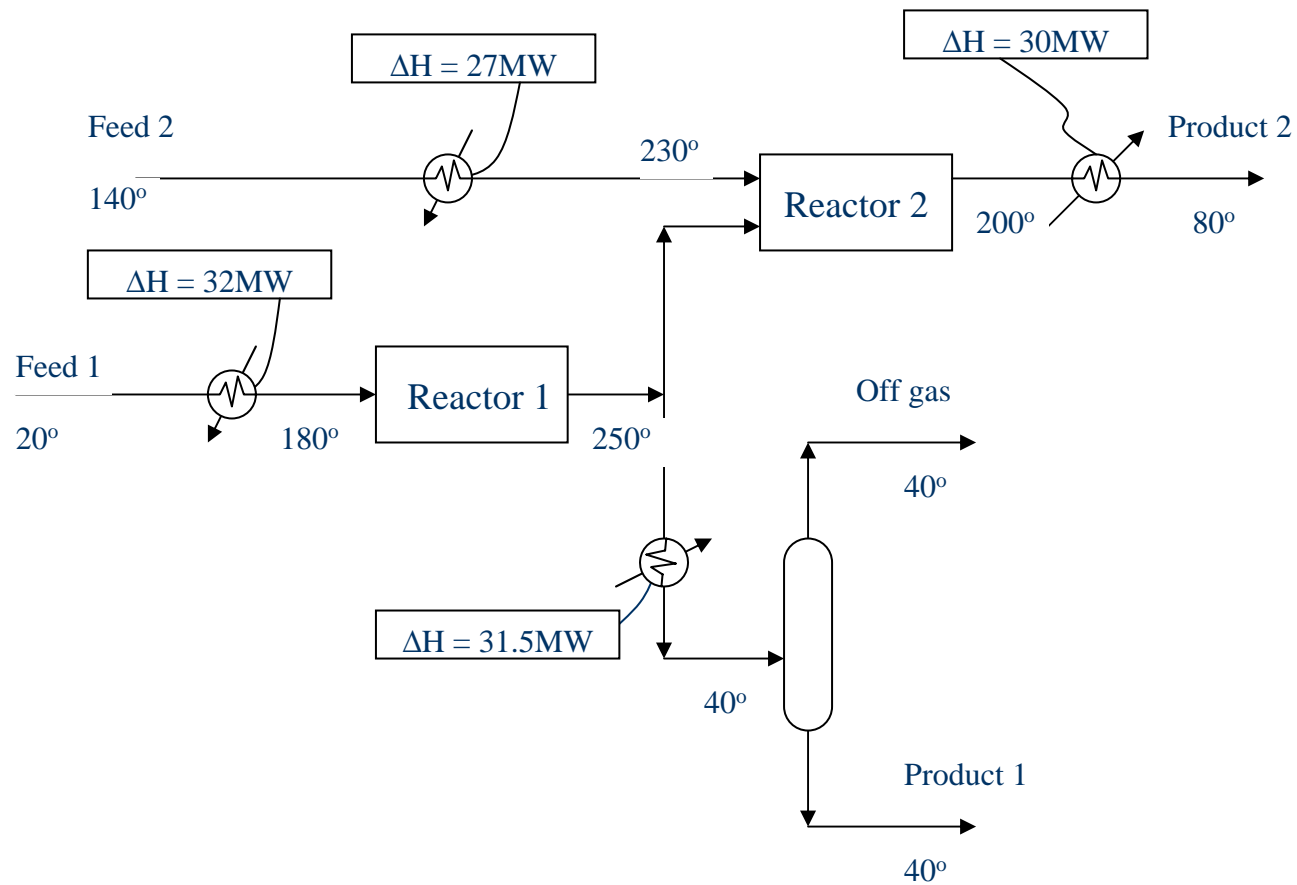
- Steam is available at 180 °C
- Cooling water (CW) is available at 20 °C



# A Simple Heat Recovery Problem with One Hot Stream and One Cold Stream



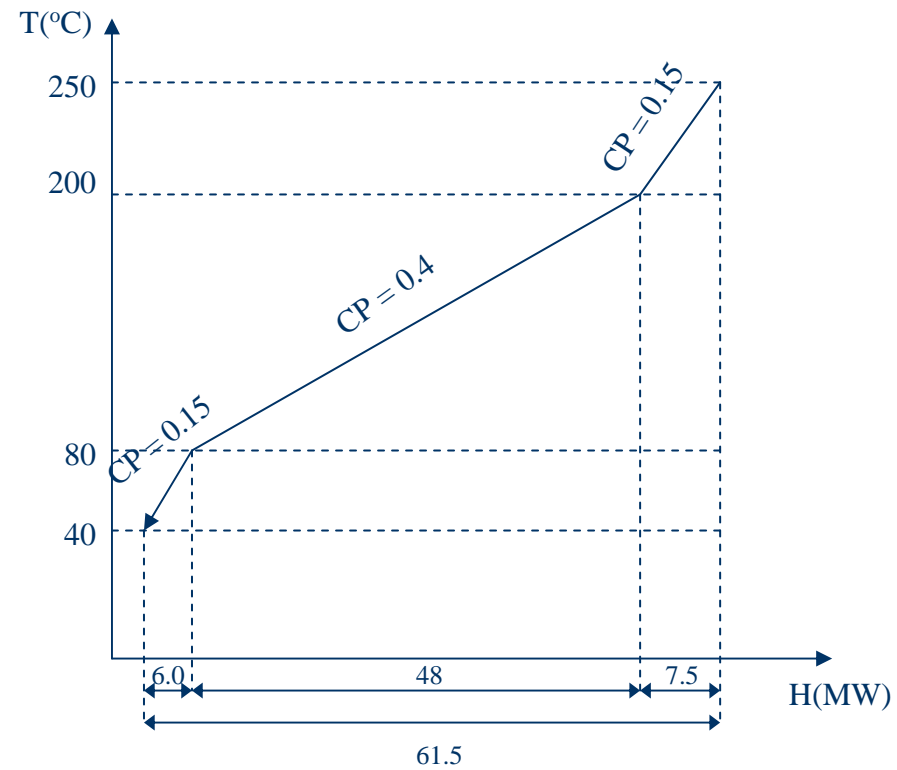
# A Simple Flowsheet with Two Hot Streams and Two Cold Streams



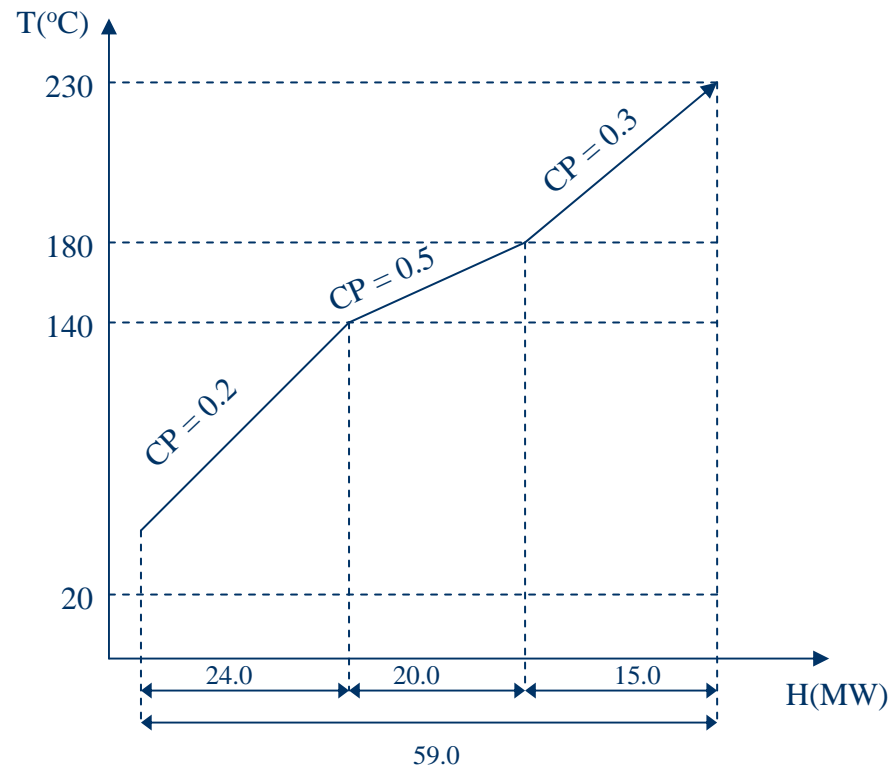
# Heat Exchange Stream Data for the Flowsheet

Stream	Type	Supply temp. $T_S$ (°C)	Target temp. $T_T$ (°C)	$\Delta H$ (MW)	Heat capacity flow rate CP (MW °C <sup>-1</sup> )
1. Reactor 1 feed	Cold	20	180	32.0	0.2
2. Reactor 1 product	Hot	250	40	-31.5	0.15
3. Reactor 2 feed	Cold	140	230	27.0	0.3
4. Reactor 2 product	Hot	200	80	-30.0	0.25

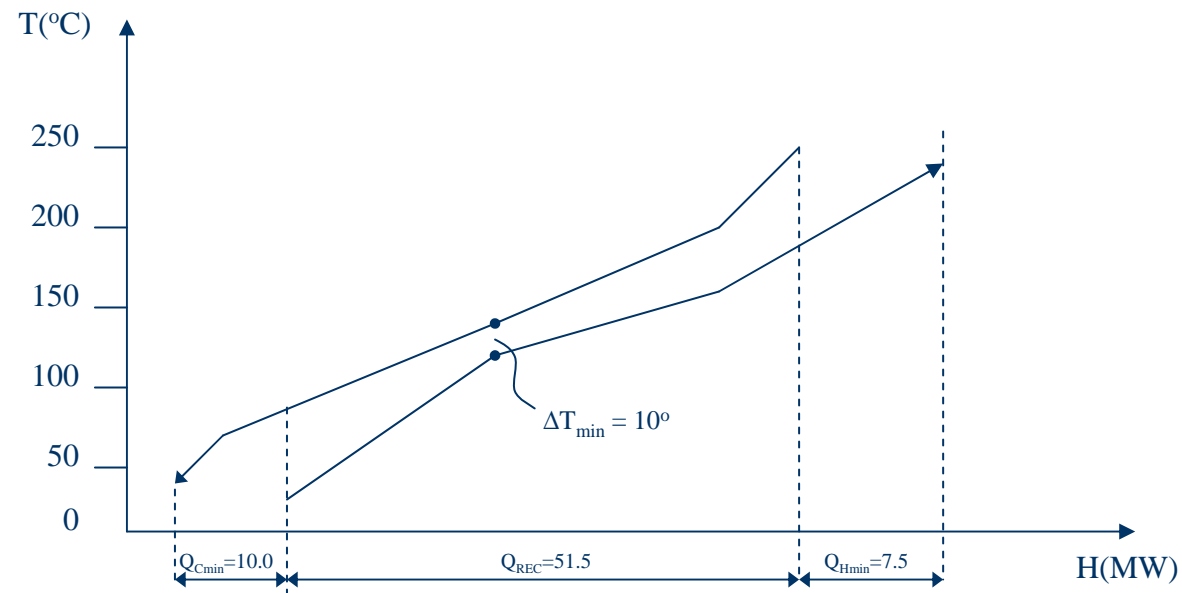
# The Composite Hot Stream



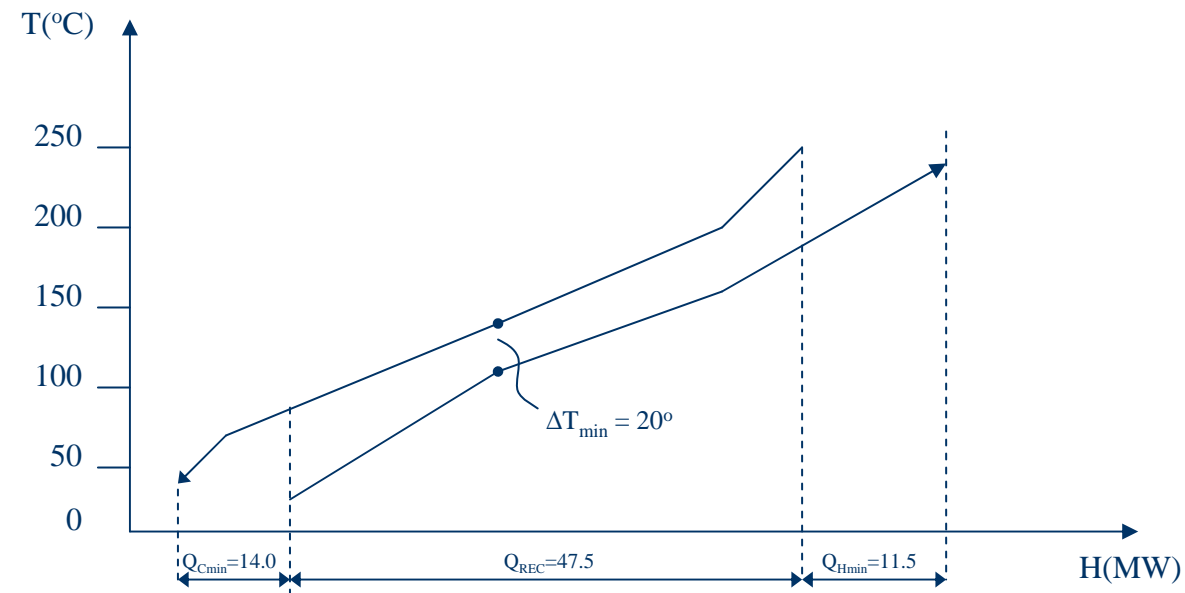
# The Composite Cold Stream



# The Hot and Cold Composite Curves Plotted together at $\Delta T_{\min} = 10^\circ$



# Increasing $\Delta T_{\min}$ from $10^\circ$ to $20^\circ$ C Increases the Hot and Cold Utility Targets



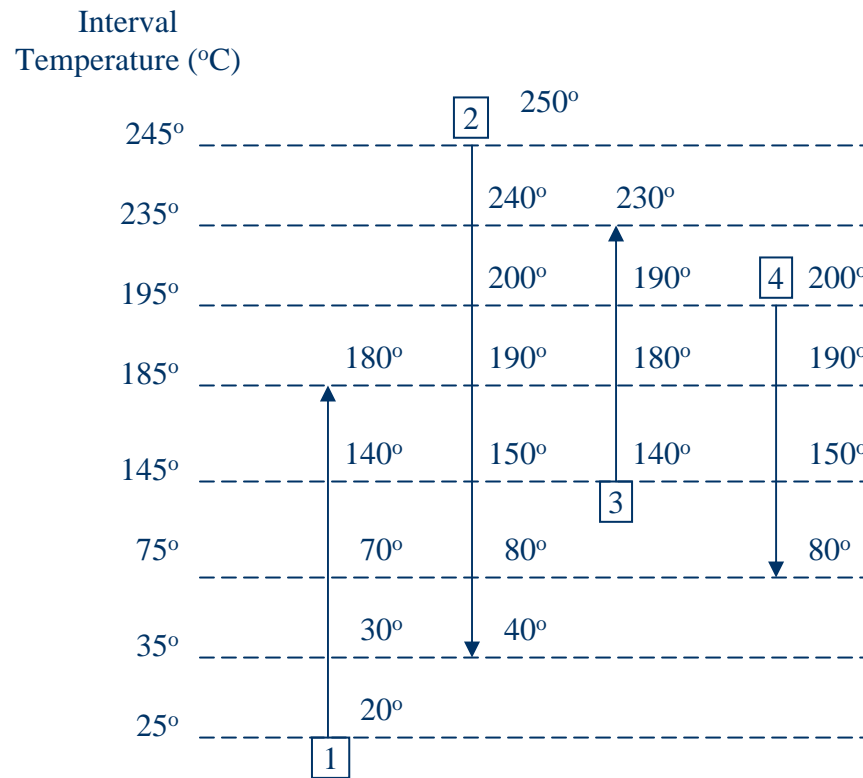
# Problem Table



# Shifted Temperatures

Stream	Type	$T_S$	$T_T$	$T^*_S$	$T^*_T$
1	Cold	20	180	25	185
2	Hot	250	40	245	35
3	Cold	140	230	145	235
4	Hot	200	80	195	75

# The Stream Population



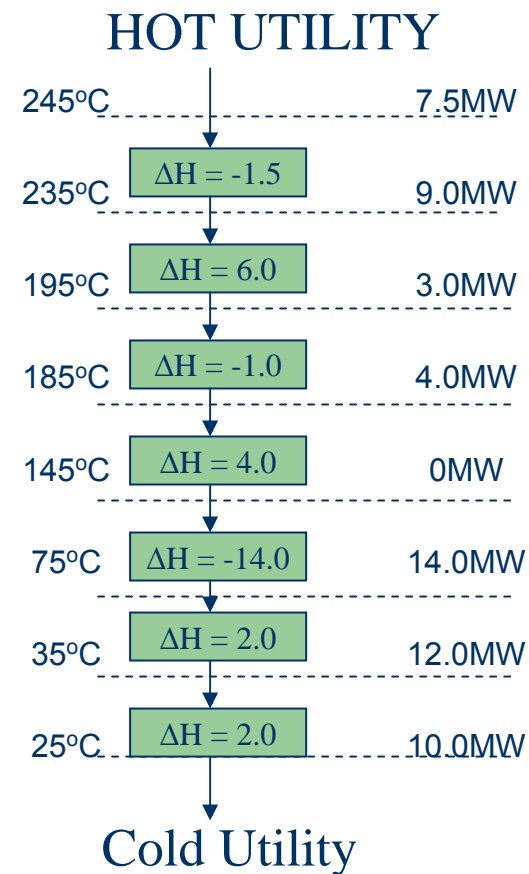
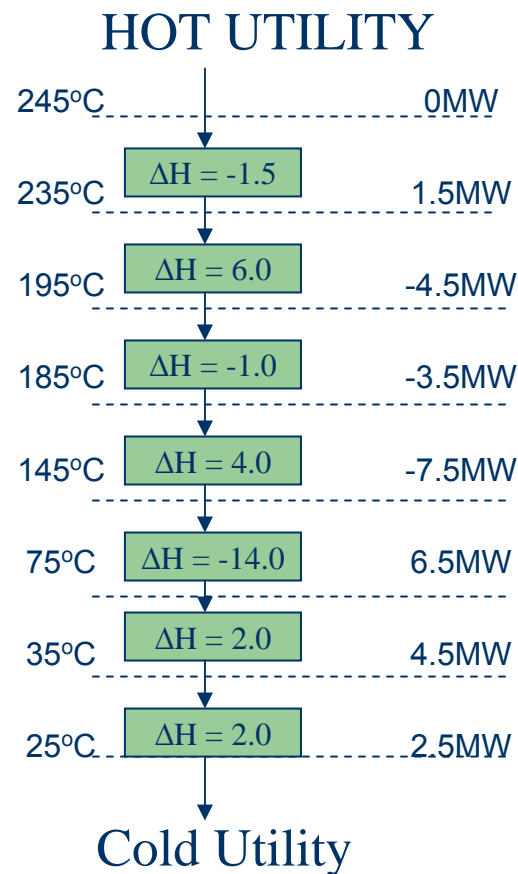
# Problem Table Algorithm

$$\Delta H_i = \left( \sum_{\text{All cold streams}} CP_C - \sum_{\text{All hot streams}} CP_H \right)_i \Delta T_i$$

# The Temperature-interval Heat Balances

Interval Temperature	INTERVAL NO.	$\Delta T_{\text{INTERVAL}}$	$\sum CP_C - \sum CP_H$	$\Delta H_{\text{INTERVAL}}$	Surplus/ Deficit
245°C	1	10	-0.15	-1.5	Surplus
235°C	2	40	0.15	6.0	Deficit
195°C	3	10	-0.1	-1.0	Surplus
185°C	4	40	0.1	4.0	Deficit
145°C	5	70	-0.2	-14.0	Surplus
75°C	6	40	0.05	2.0	Deficit
35°C	7	10	0.2	2.0	Deficit
25°C					

# The Problem Table Cascade



# The Problem Table Cascade

- If cold streams dominate hot streams, the interval has a net deficit of heat, and  $\Delta H$  is positive.
- If hot streams dominate cold streams, the interval has a net surplus of heat, and  $\Delta H$  is negative.
- Any excess heat available from hot streams in an interval is hot enough to supply a deficit in the cold streams in the next interval down.
- The smallest amount of heat needed from a hot utility is the largest negative heat flow.