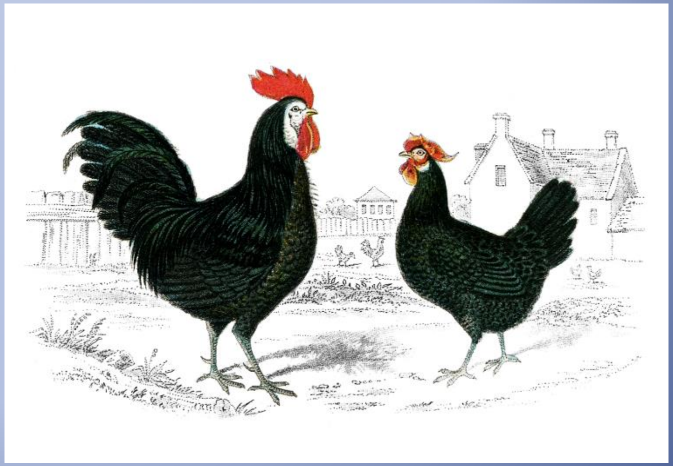
Pinch Technology

Optimization of heat exchange

How to design a HEN



Pinch Technology – whose idea

- Developed by Bodo Linnhof PhD thesis at Leeds University 1977

*and D.R. Vredeveld. What happened to him?

- Joined ICI and in 1982 Uni of Manchester
- At 33 full professor
- Started Linnhof March consultancy in 1983
- Sold to KBC Advanced Technologies in 2002
- Retired to do other things

What is Pinch technology?

- Methodology for making energy savings
- Based on thermodynamic principles

  First law - energy conservation

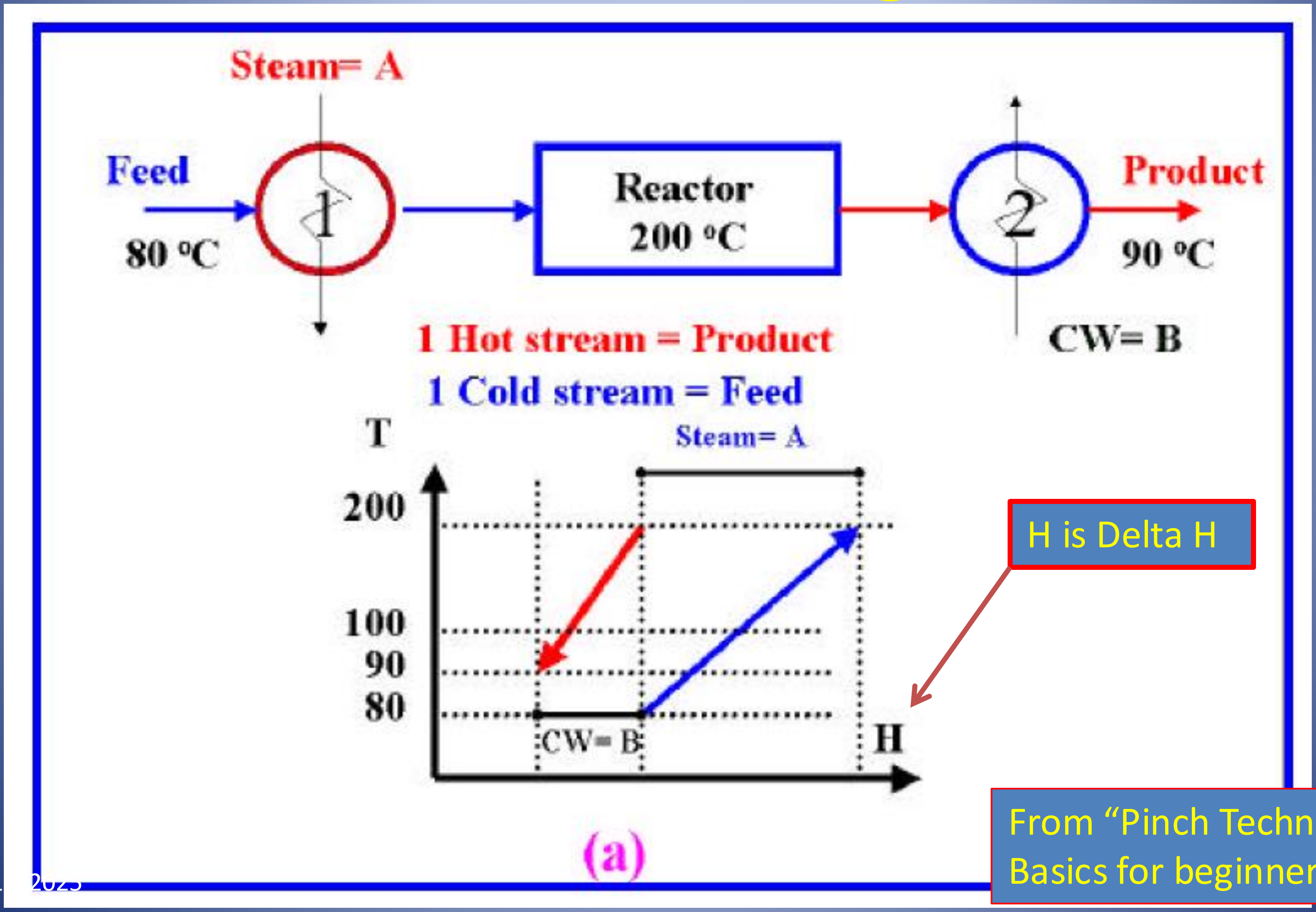
  Second law – heat cannot pass from a colder to a warmer body; entropy increases
- Provides a way to calculate minimum theoretical use of external utilities

  (hot and cold)

Purpose

- Determine minimum theoretical use of external utilities in a plant
- Reduce energy consumption
- Reduce capital cost of heat exchange equipment
- Minimize aggregate capital cost + operating cost of heat exchange
- Set targets for energy saving
- Reduce emissions (CO_2, SO_2, NOX)

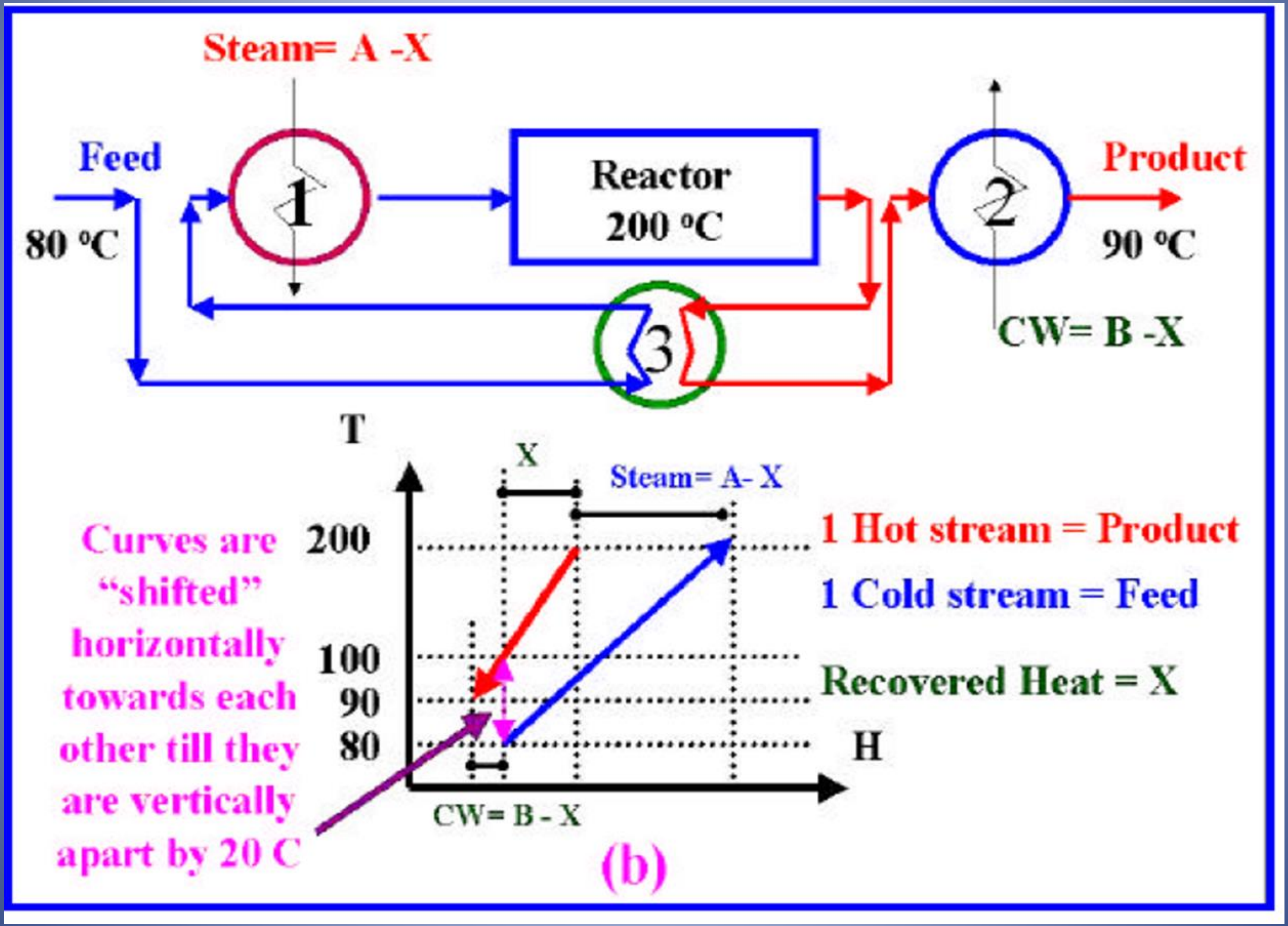
Simple reactor, no process heat exchange



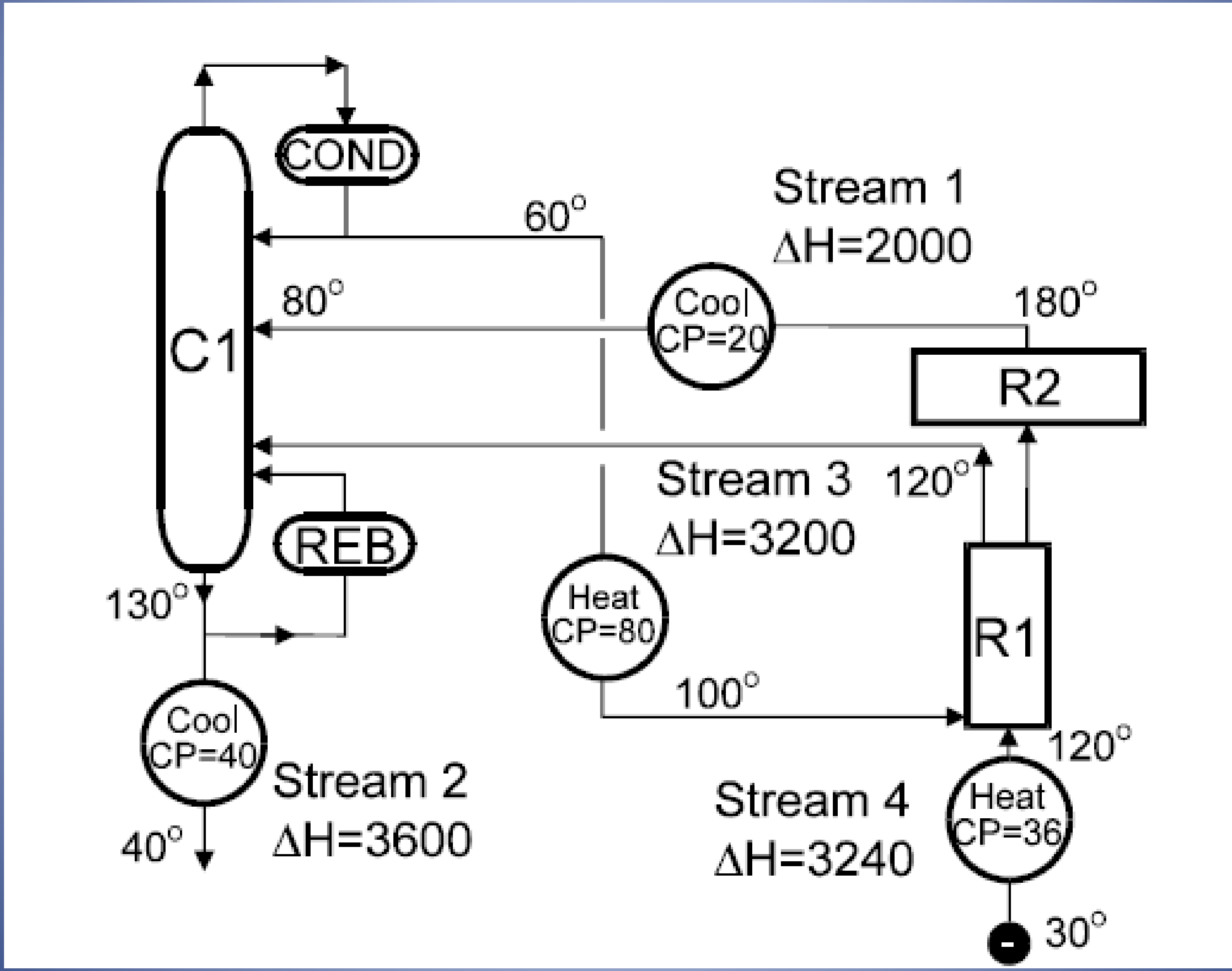
H is Delta H

From "Pinch Technology: Basics for beginners"

Reactor system with feed/effluent exchanger



Data Extraction flowsheet



Stream Number	Stream Type	Start Temperature (^{O}c)	Target temperature (^{O}c)	Heat capacity ($kW/^{O}c$) rate
1	Hot	180	80	20
2	Hot	130	40	40
3	Cold	60	100	80
4	Cold	30	120	36

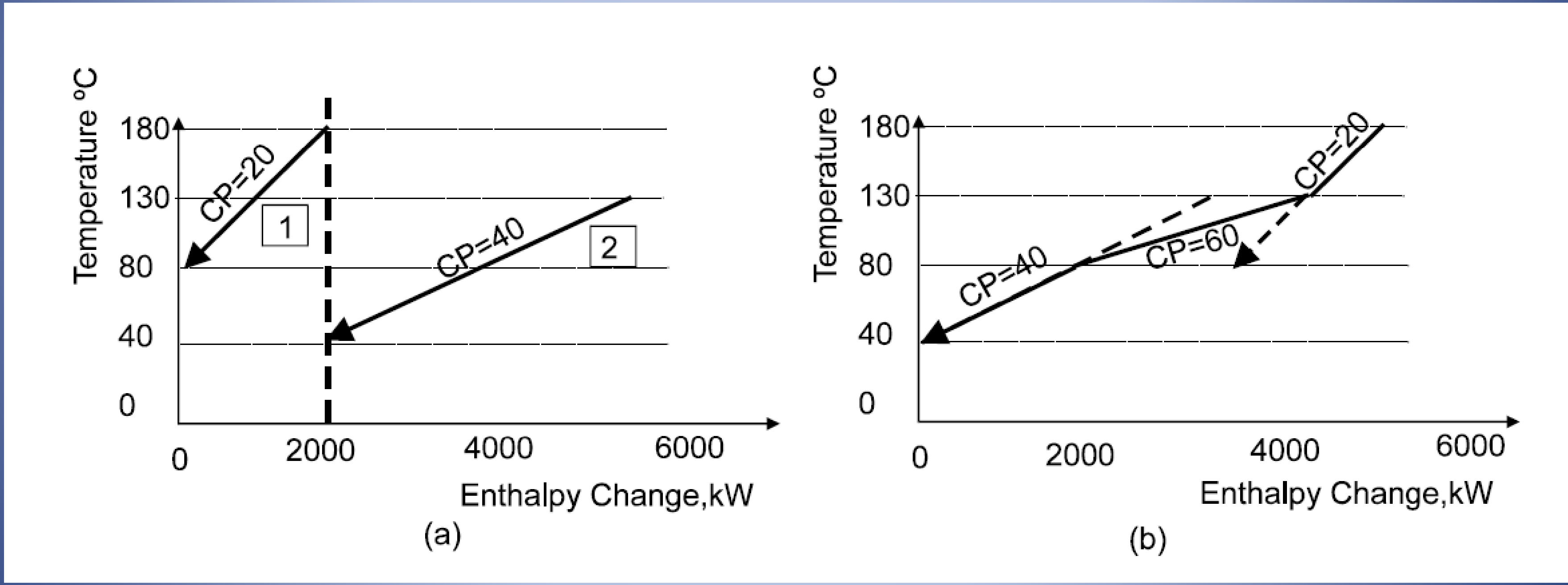
Extract thermal data

ΔT min = 10degC

Utilities steam at 200^{O}c Cooling water at 25^{O}c to 30^{O}c

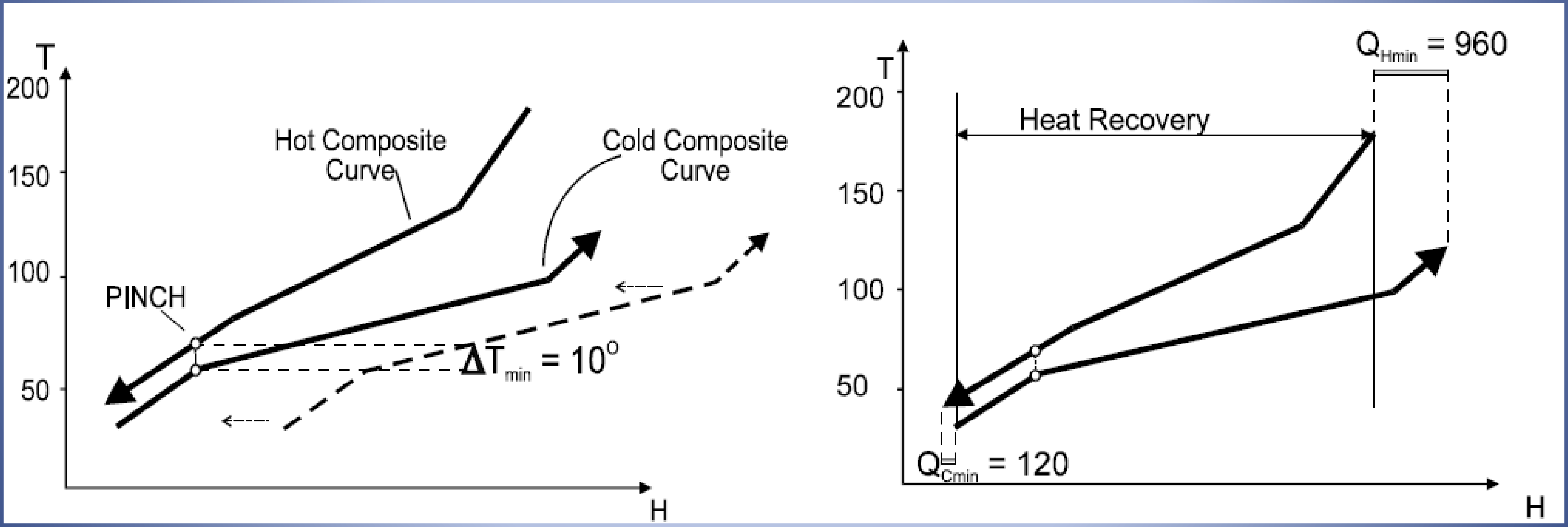
Construction of hot and cold composite curves

This is the hot one – streams getting colder

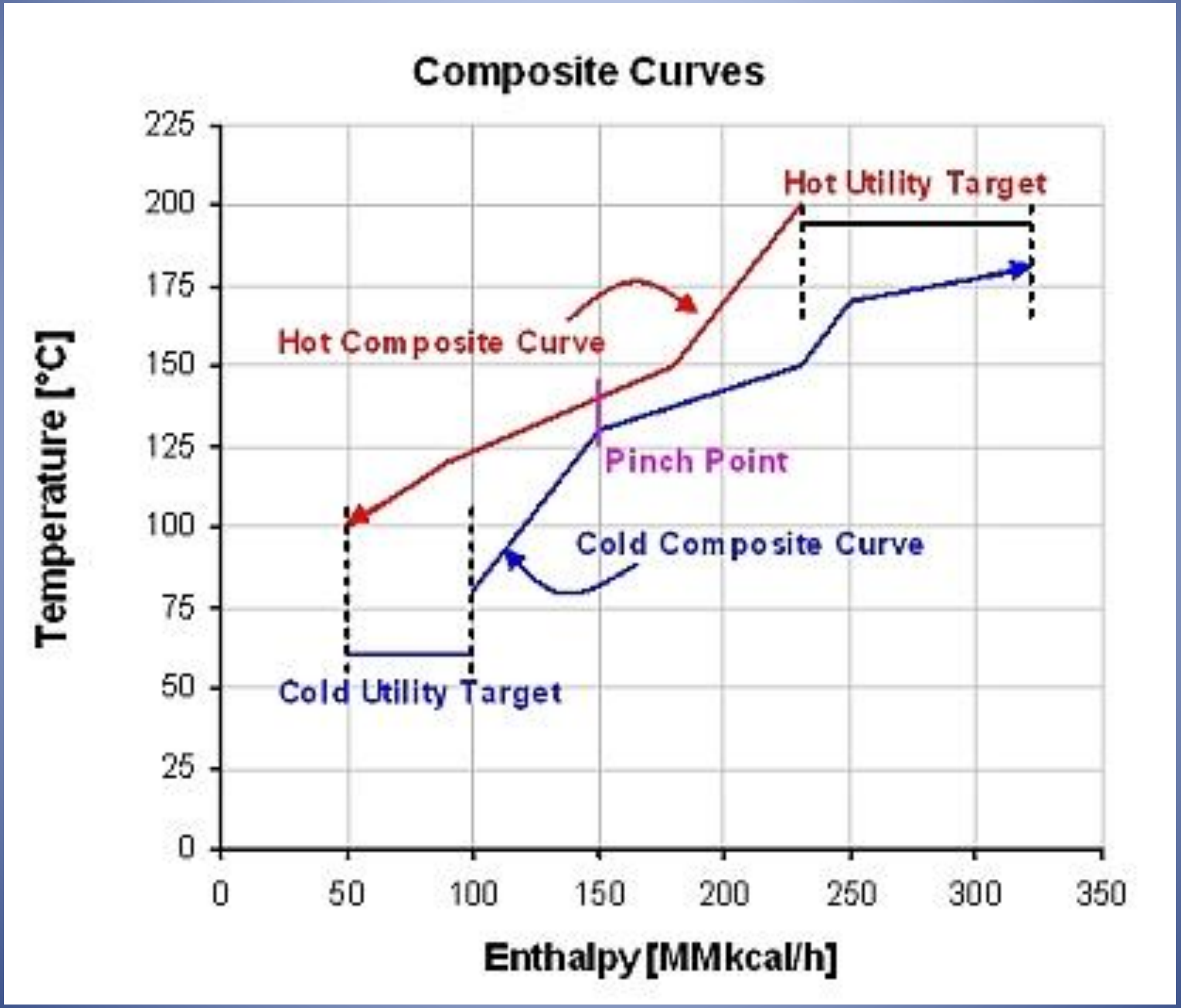


Hot and cold composite curves

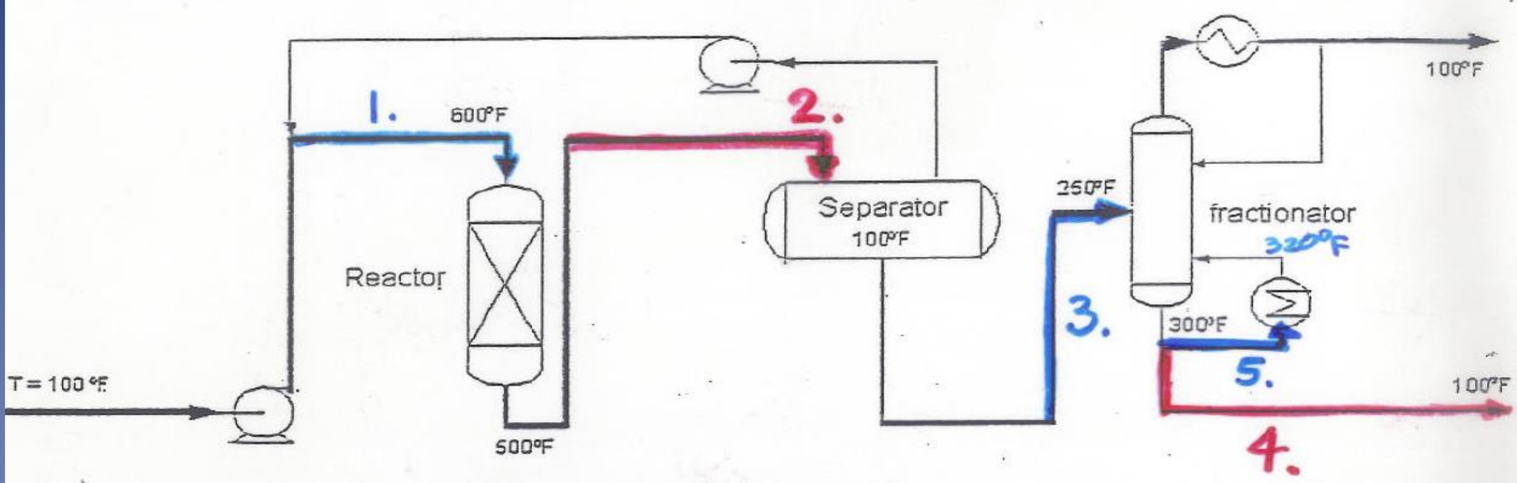
energy targets for hot and cold utilities



Composite curve two streams



• Cool streams need heating.   • Hot streams need cooling



Temperature lines

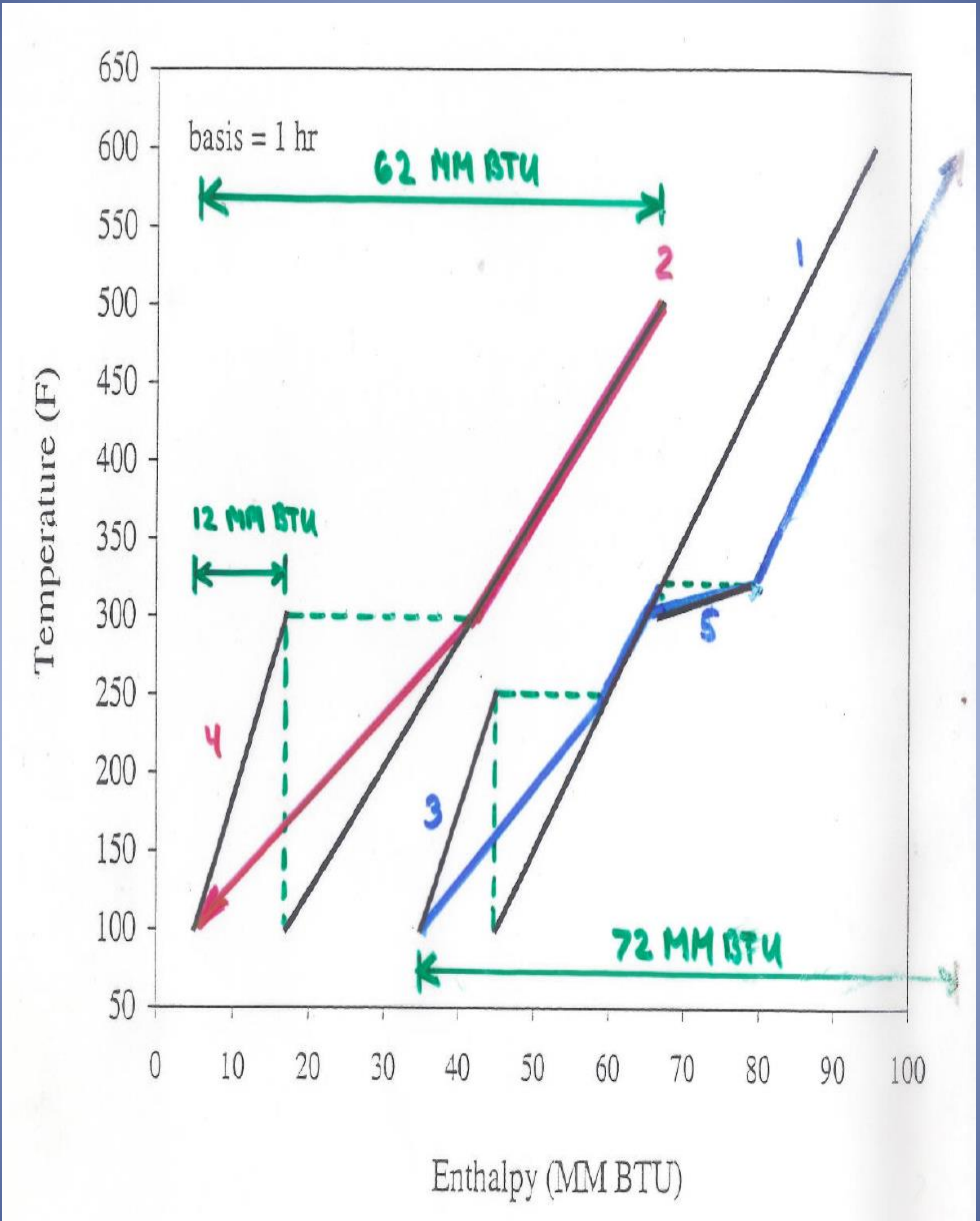
		T°F		Btu/Hr
1	RX FEED	100	→ 600	Q = 50MM
2	RX EFFLUENT	100	← 500	Q = 50MM
3	FRAC. FEED	100	→ 250	Q = ~~20~~ 10 MM
4	FRAC. BOTTOMS	100	← 300	Q = 12MM
5	REBOILER		300 → 320	Q = 12MM

Heating Demand: 50 + 10 + 12 = 72

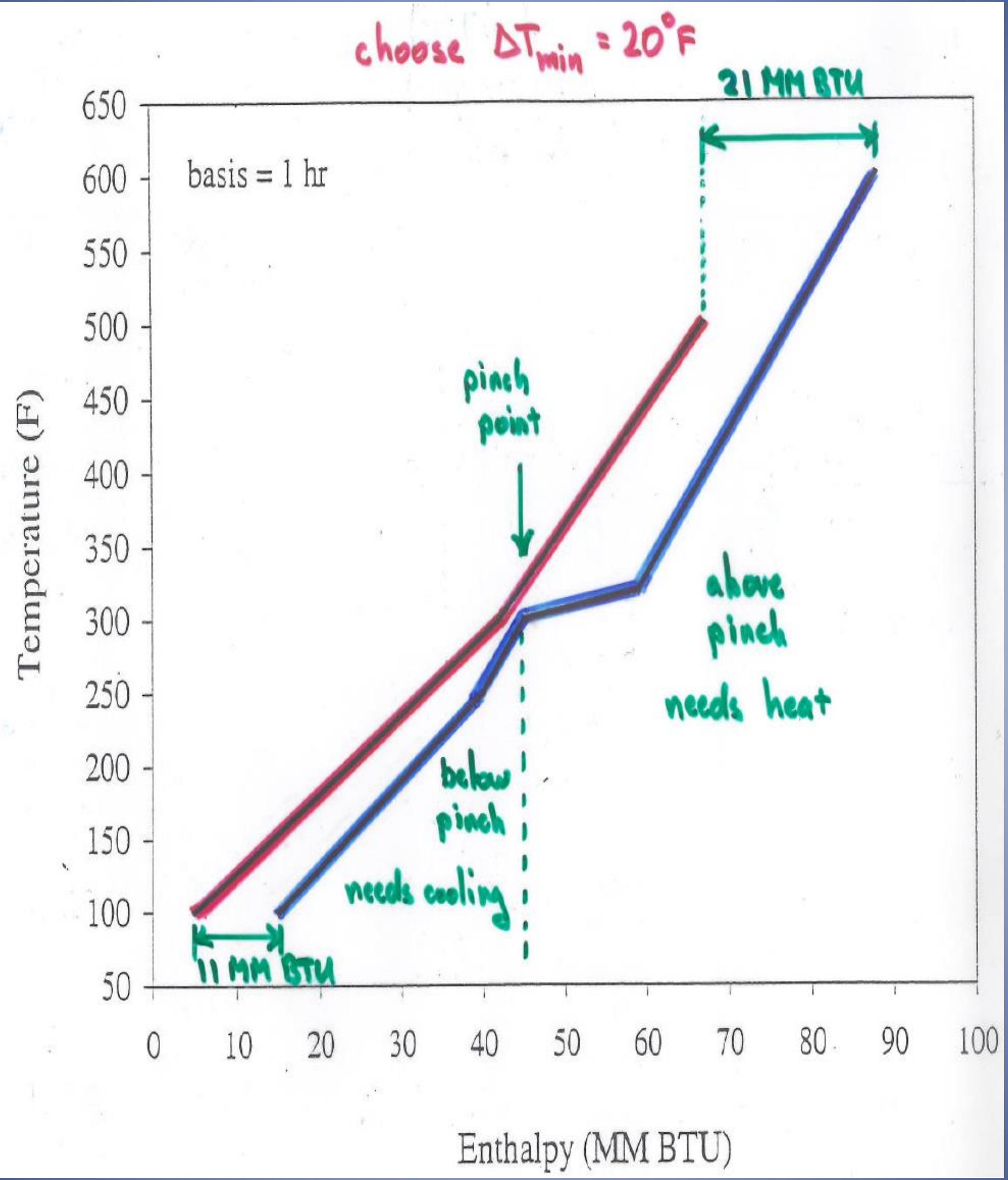
Cooling Demand: 50 + 12 = 62

Heat needed: 72 − 62 = 10 mm BTU

1st Law Analysis

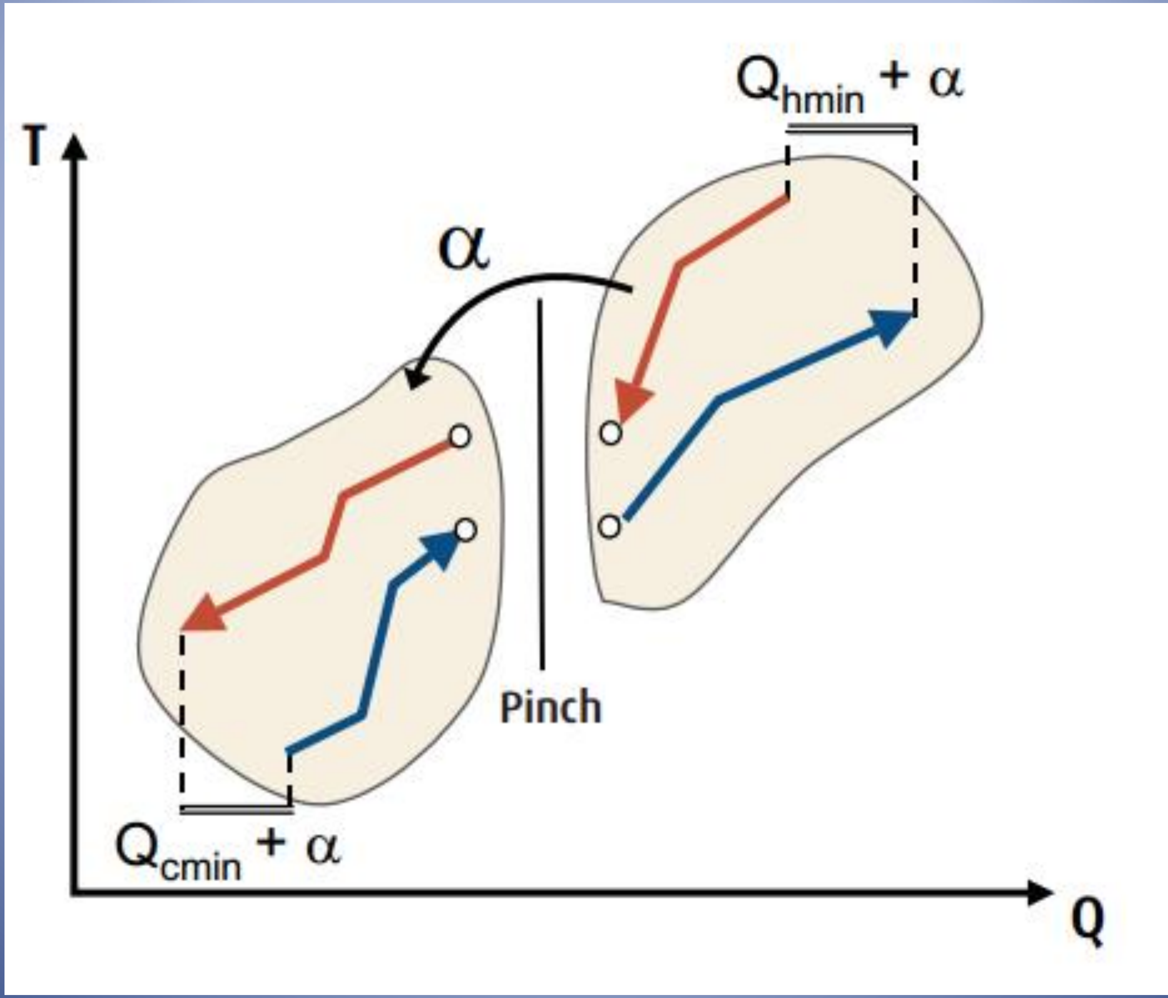


basis = 1 hr
62 MM BTU
12 MM BTU
72 MM BTU
1
2
3
4
5
Temperature (F)
Enthalpy (MM BTU)
650
600
550
500
450
400
350
300
250
200
150
100
50
0
10
20
30
40
50
60
70
80
90
100



choose ΔT_{min} = 20°F
21 MM BTU
basis = 1 hr
pinch point
above pinch
needs heat
below pinch
needs cooling
11 MM BTU
Temperature (F)
650
600
550
500
450
400
350
300
250
200
150
100
50
0
10
20
30
40
50
60
70
80
90
100
Enthalpy (MM BTU)

The Pinch principle
Don't transfer heat across the pinch



Pinch rules

Do not transfer heat across the pinch

α

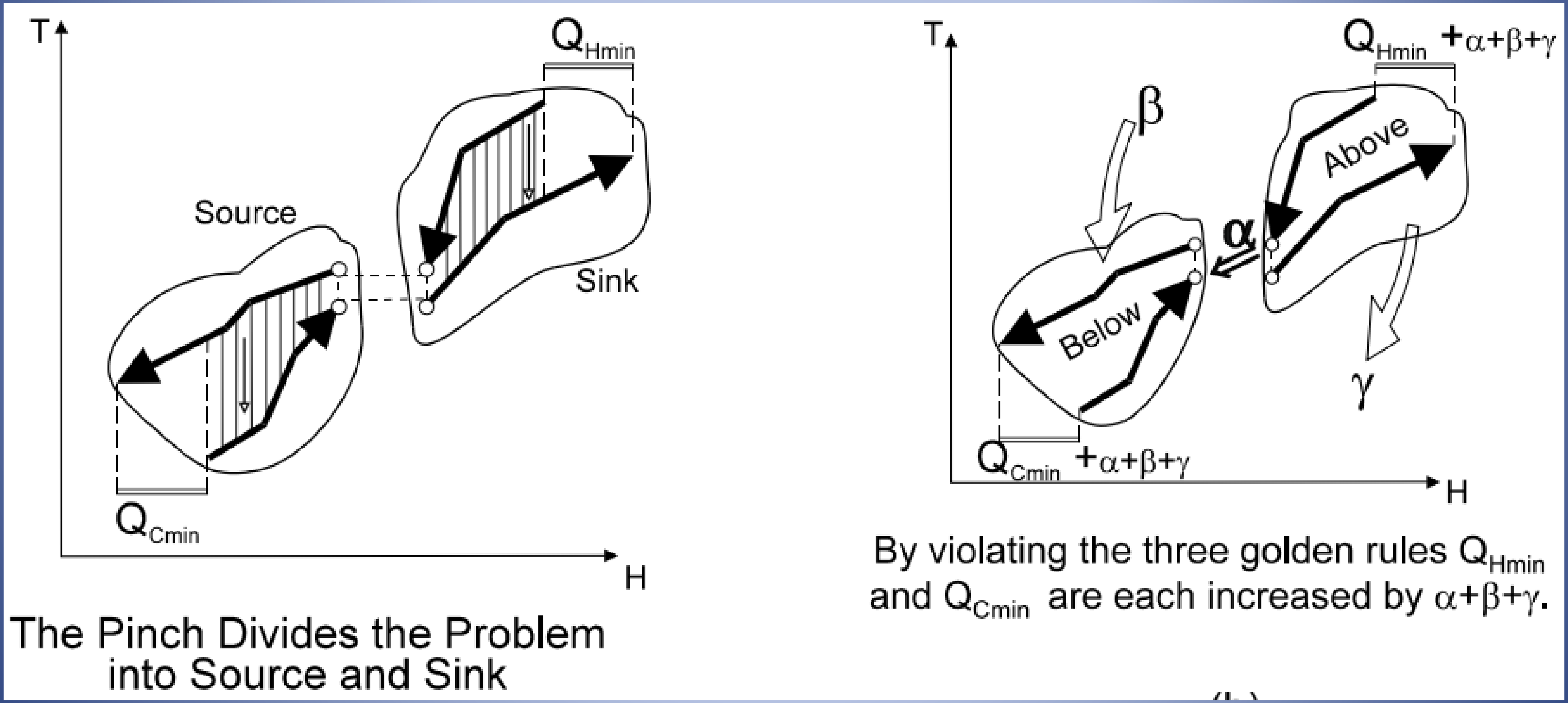
Do not use hot utility below the pinch (no external heating)

β

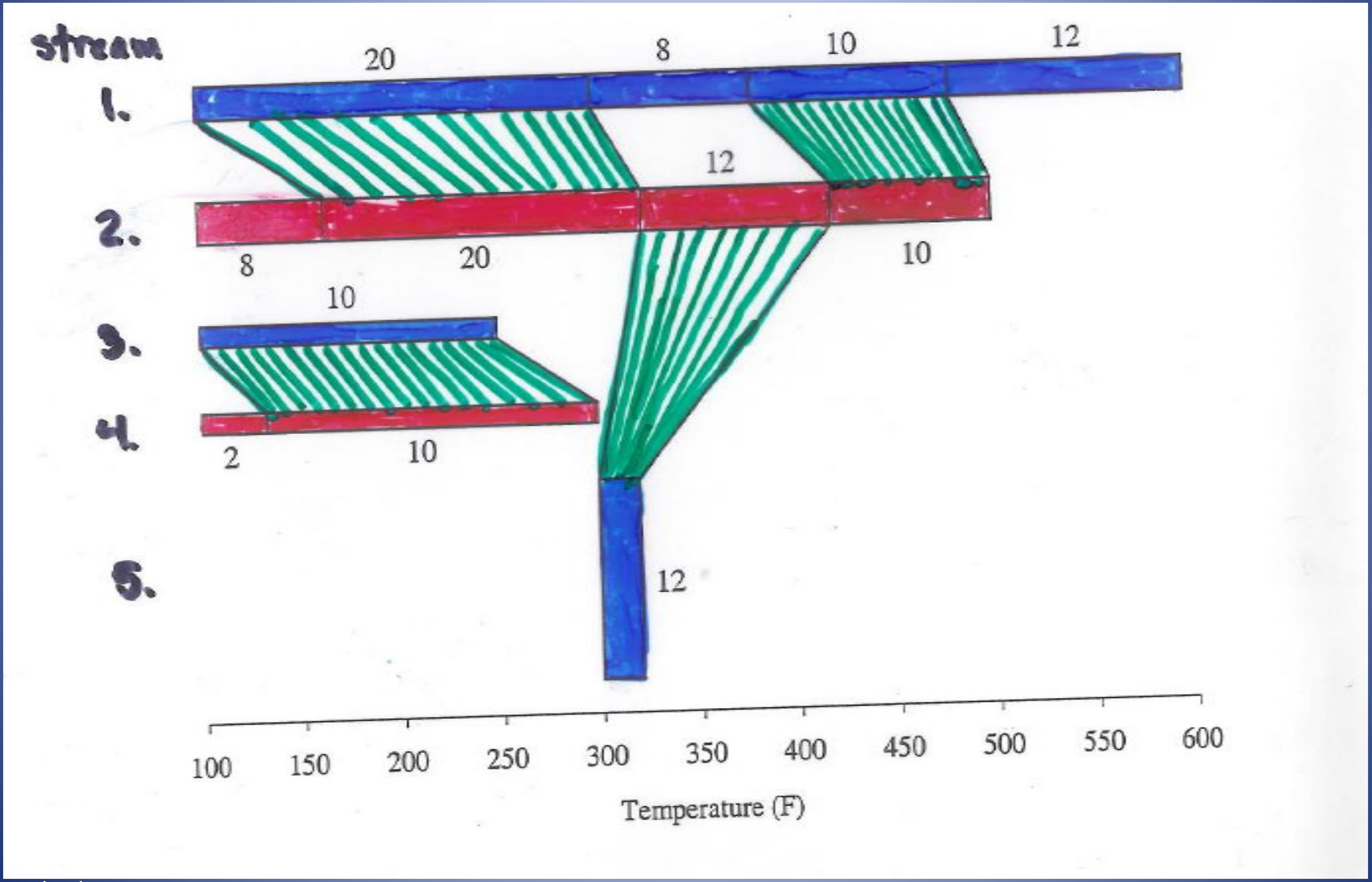
Do not use cold utility above the pinch (no external cooling)

γ

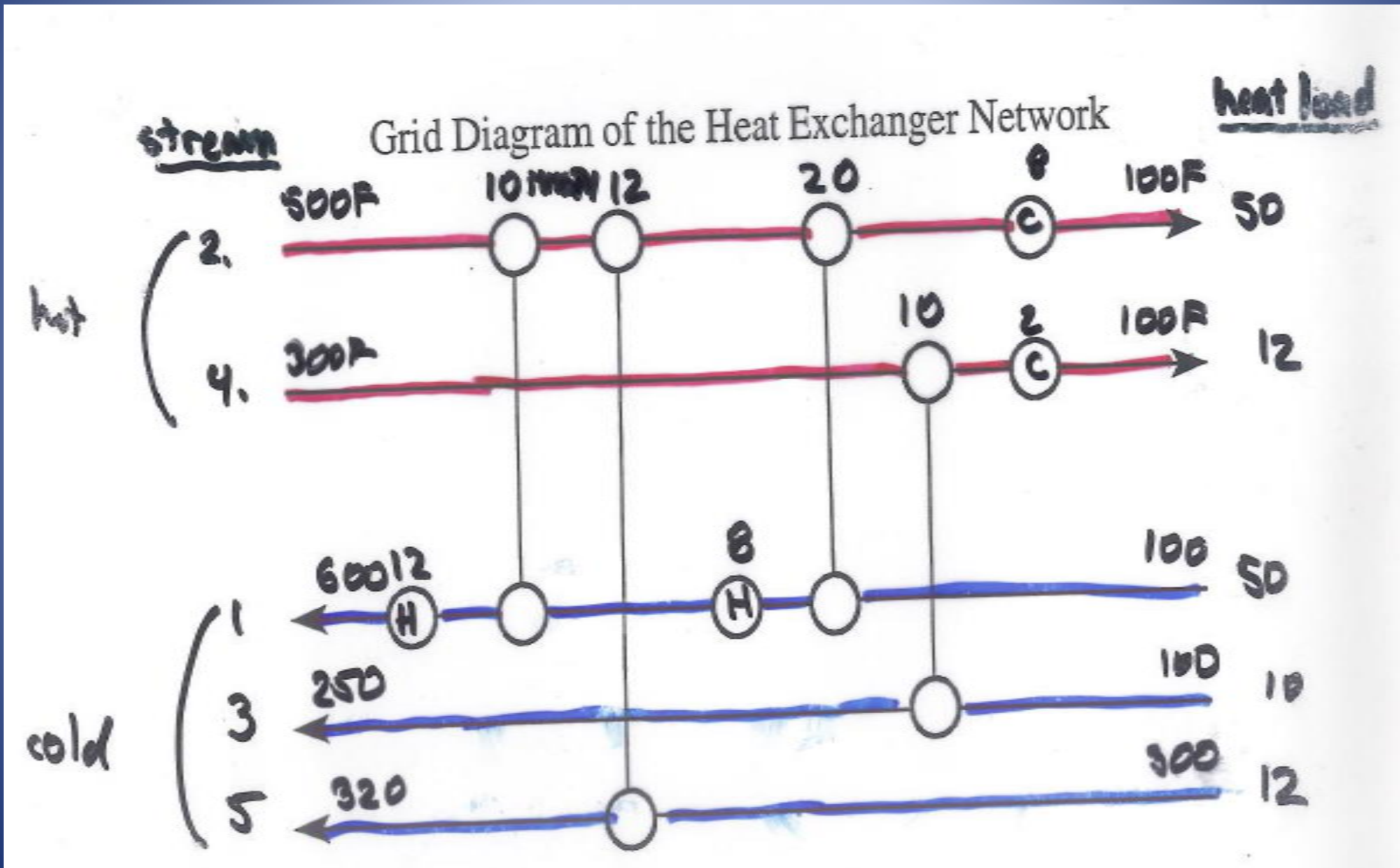
No hot utility below pinch **(β)**
No cold above the pinch (γ)



Heat Capacity block diagram



HEN grid diagram



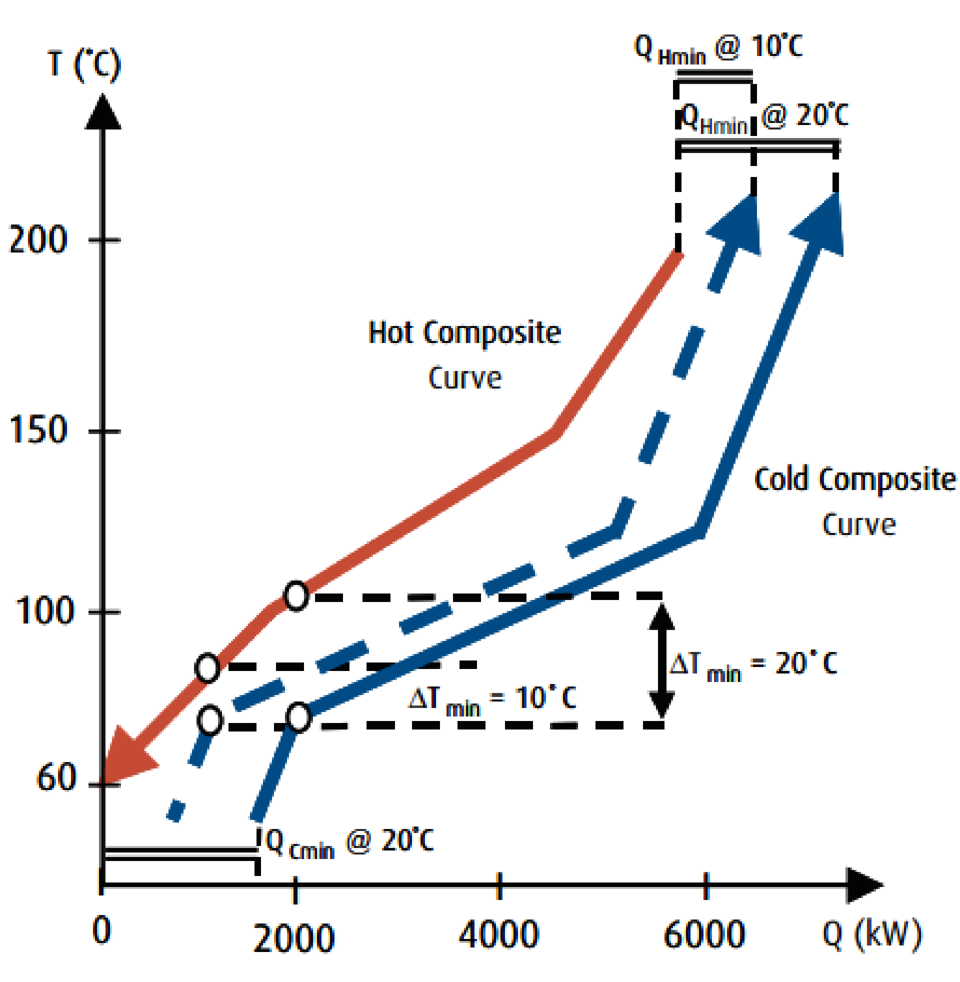
Selection of ΔT min

- Low ΔT min leads to lower energy costs (utility circulation rate) but higher capital costs (heat exchange area).
- High ΔT high energy costs low capital costs

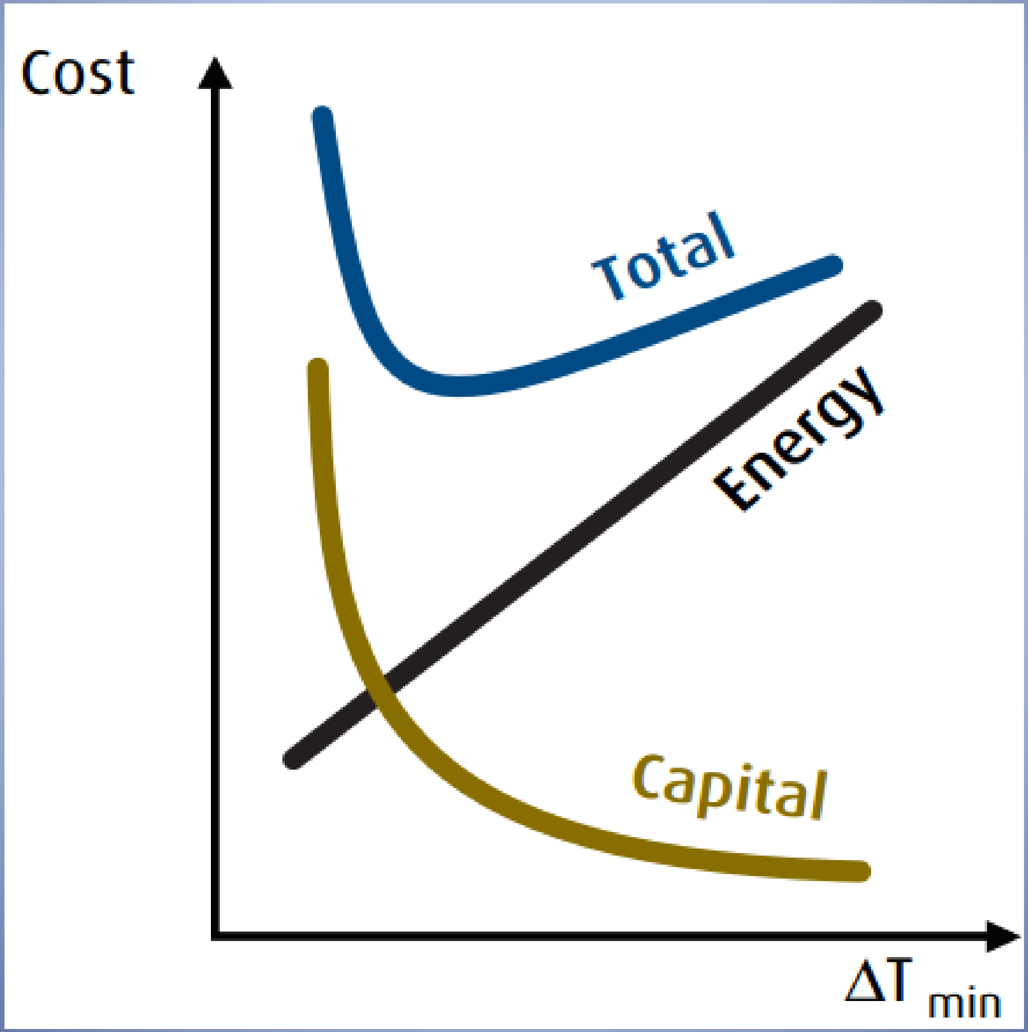
Industry	Common ΔT Min degC	Comments
Oil refining	20 – 40	Low heat transfer coefficients. Fouling of exchangers
Petrochemical & Chemical	10 – 20	Reboilers & condensers better HT coefficients, low fouling
Low Temperature	3 – 5	Power for refrigeration $$$. Use lower ΔT with low refrigerant temp

Effect of reducing Δ T min

reduced minimum utility requirement but larger exchangers



Energy operating costs vs Capital



Limitations to the technique

- Don’t join different process plants
- Be cautious joining different parts of same plant
  - e.g. heat exchange from one reactor system to another
- Make sure all the capital cost of heat exchange equipment is properly accounted for
  - e.g. long runs of alloy piping
- Be careful using in condensers and reboilers
  - Consider start-up and shut-down & Process control

References

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* On Canvas CHEME4620>FilesWaste Plastic Recycle Plant Project>Heat Exchange Pinch Technology