Heat exchanger network design

Pinch design method
Example

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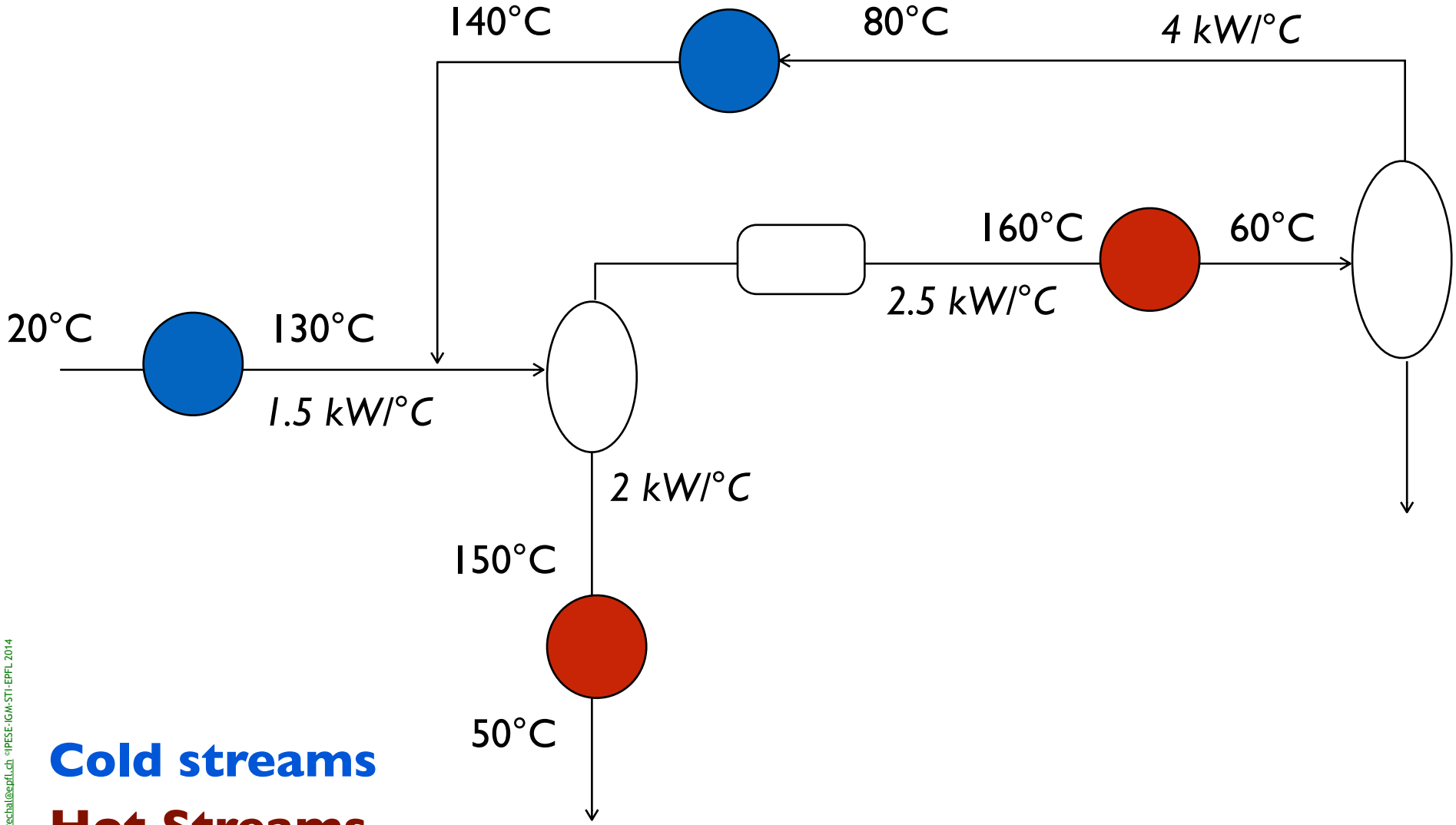
Example process



Cold streams

Hot Streams

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Streams definition

	T_{in} [C]	T_{out} [C]	$\dot{M}cp$ [kW/C]	$\dot{Q}$ [kW]	α $[kW/C/m^2]$
A	20	130	-1.5	-165.0	0.5
B	80	140	-4.0	-240.0	0.5
C	160	60	+2.5	250.0	0.5
D	150	50	+2.0	200.0	0.5

Table 1: Streams definition

Cold streams

Hot Streams

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Hot and cold composite curves

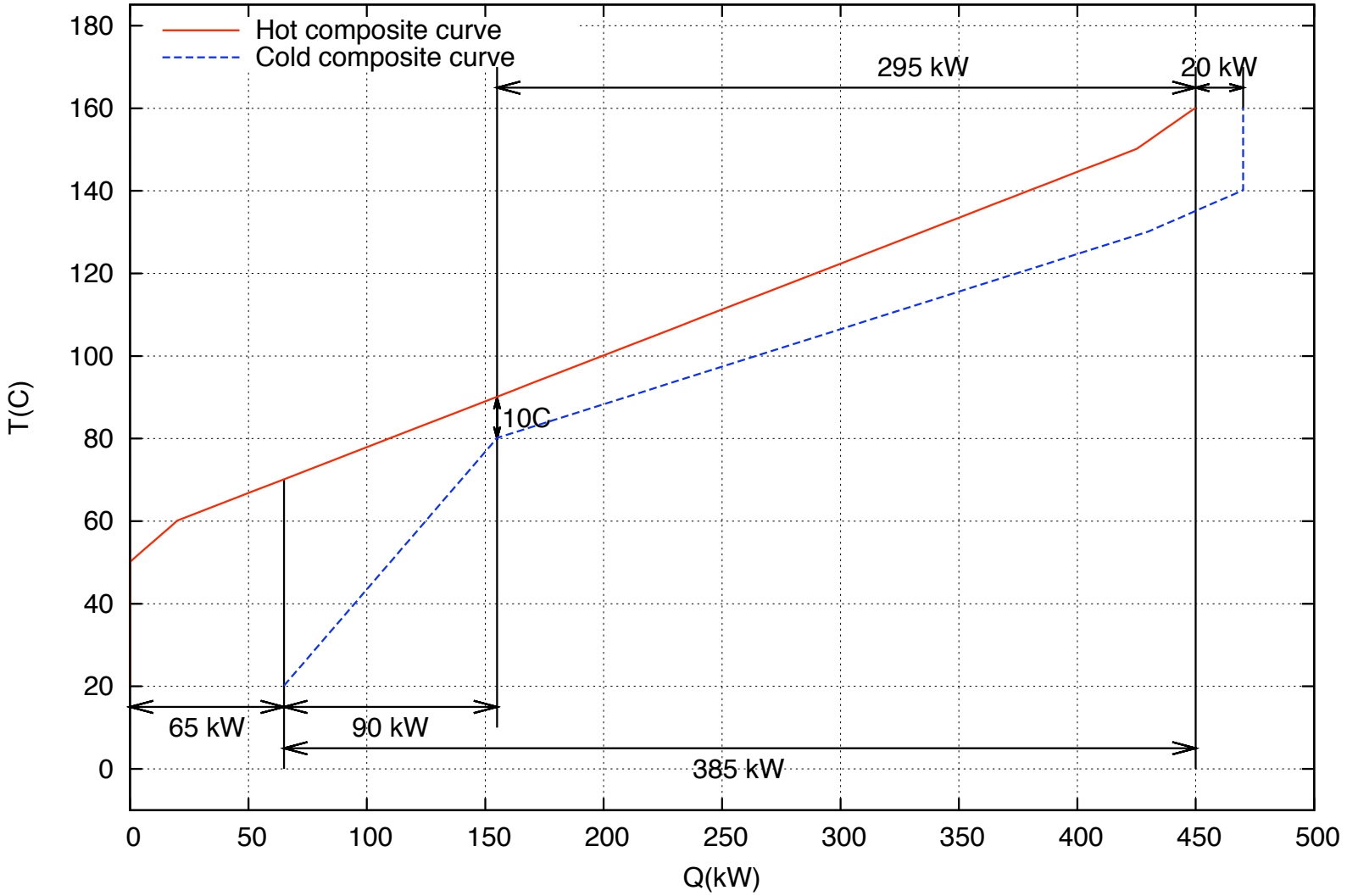
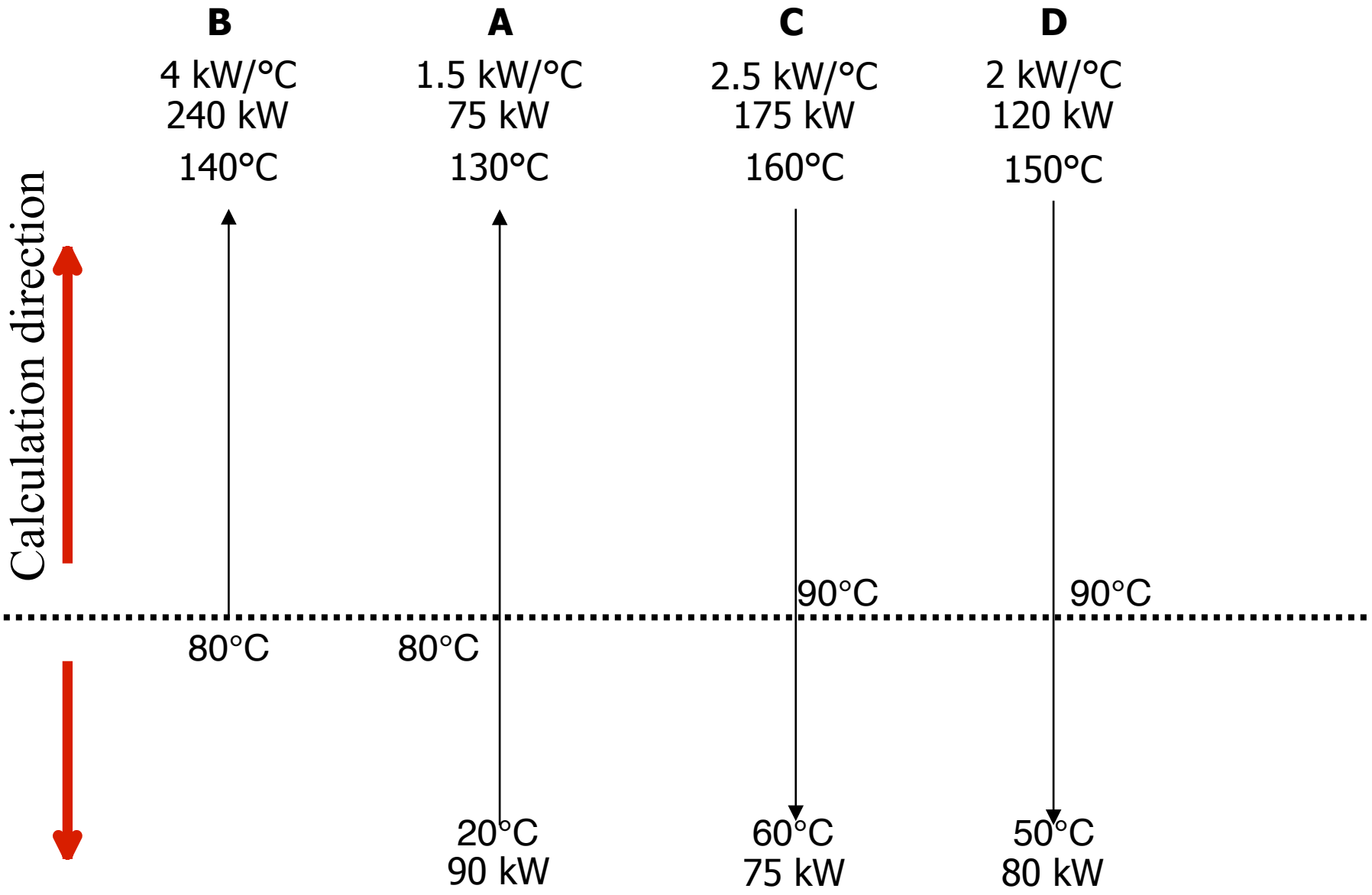


Figure 2: Hot and Cold Composite Curves

Streams grid



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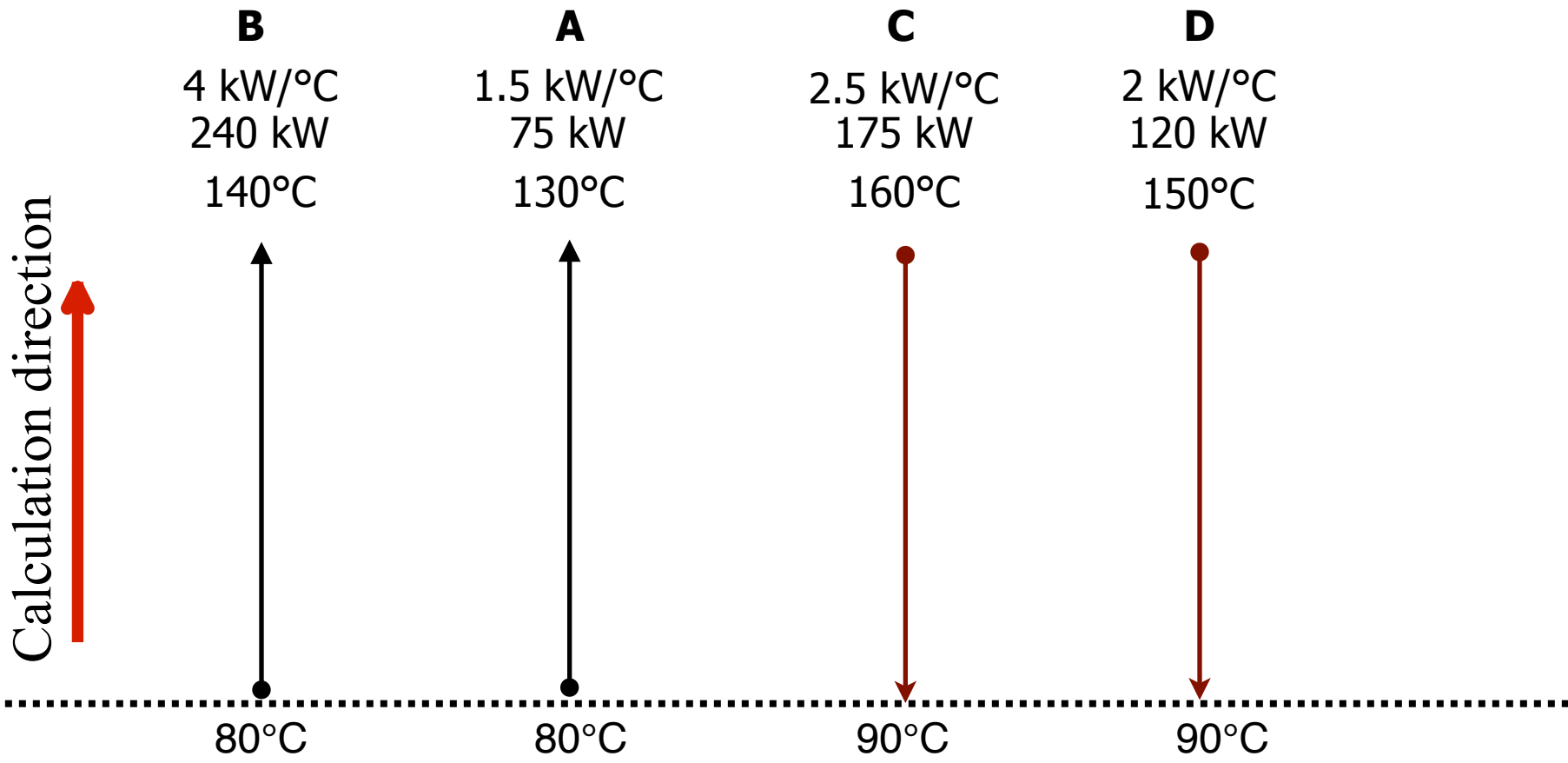
Above the pinch point : nb of streams rule ?



$$N_{pinch,c} \geq N_{pinch,h} \; ?$$

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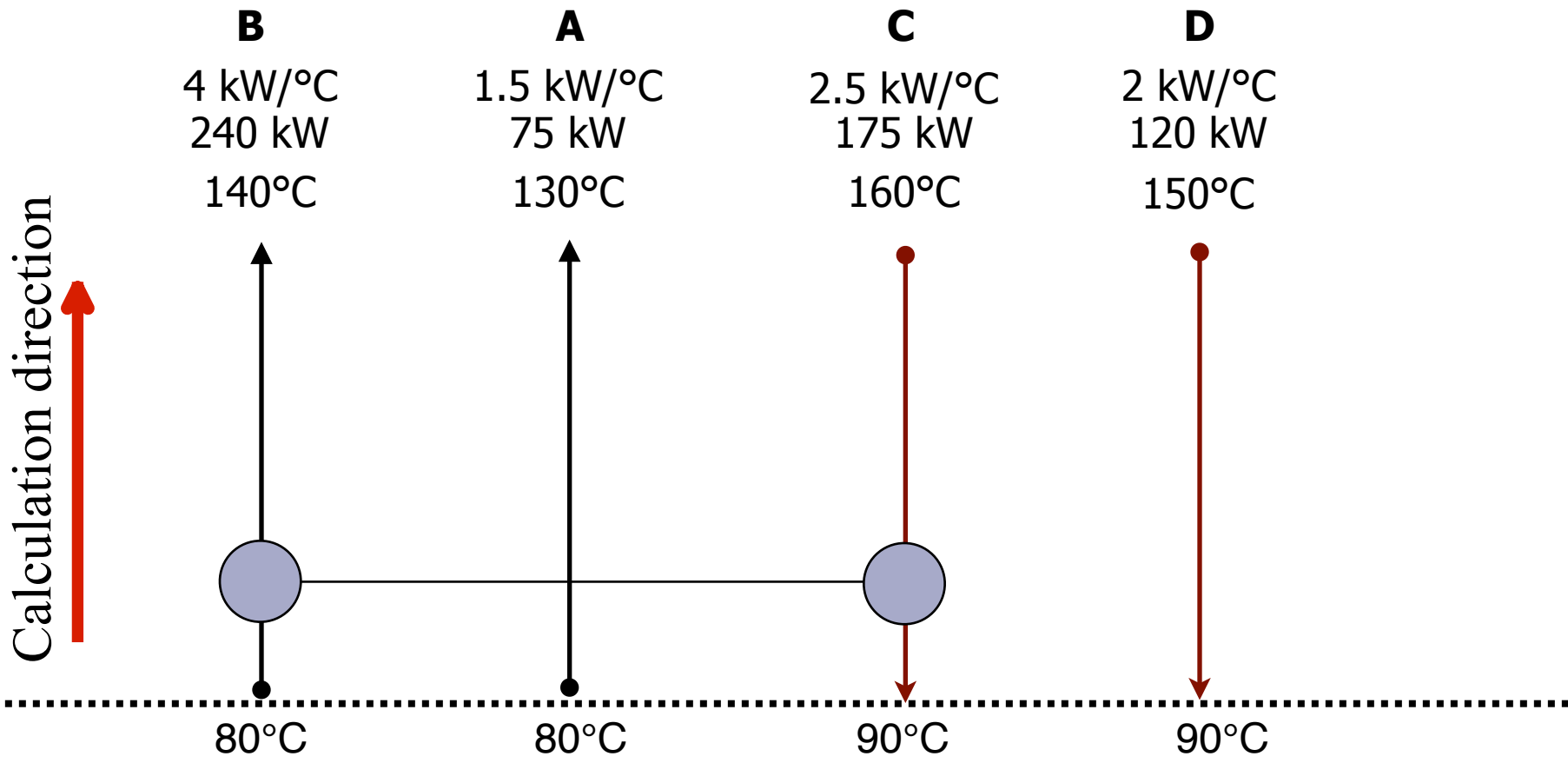
Above the pinch point : CP rule ?



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

=> Split Hot stream

? $\sum_{k=1,k\neq h}^{n_k} \dot{M} c_{\mathrm{p}\,k} \leq \sum_{j=1,j\neq c}^{n_{k-1}} \dot{M} c_{\mathrm{p}\,j}$ No

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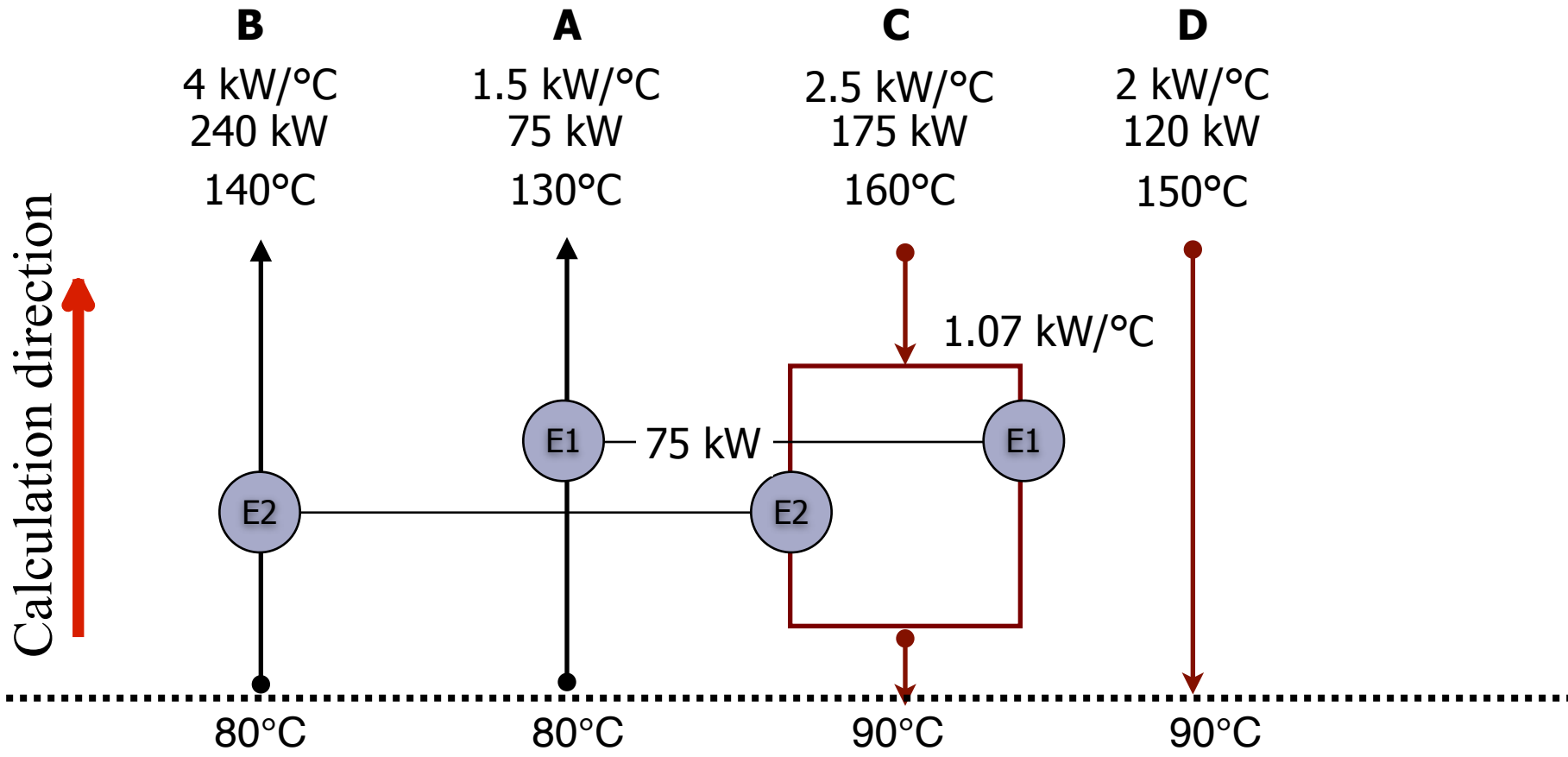
Split Hot stream => Calculate E1



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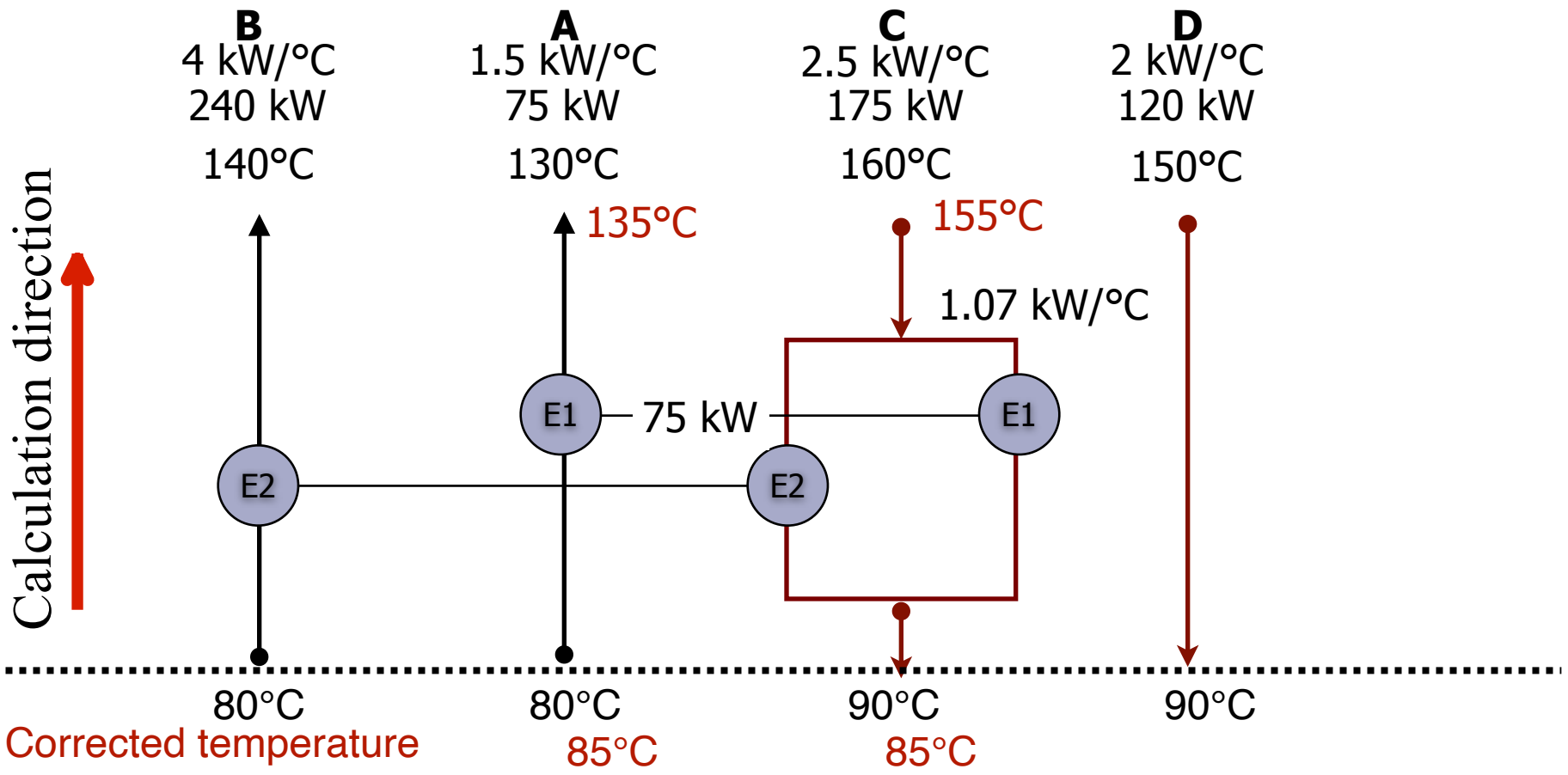
Calculating E1 : overall heat transfer coefficient 0.25 kW/m2/C



Q= 1.5 *(135 -85) = 75 kW (from the cold side)

Q= 1.5 *(130 -80) = 75 kW (from the cold side)

mcp= 75/(155 -85) = 1.07 kW/°C (split factor from the hot side side)

mcp= 75/(160 -90) = 1.07 kW/°C (split factor from the hot side side)

AU = 75/(((155-135+10)-(85-85+10))/ln((155-135+10)/(85-85+10)))

AU = 75/(((160-130)-(90-80))/ln((160-130)/(90-80))) = 4.16

=> **A=4.16/0.250= 16.5 m2**

New streams after placement of E1

- C1,2 = below the pinch

	T_{in} [C]	T^*_{in} [C]	T_{out} [C]	T^*_{out} [C]	$\dot{M}cp$ [kW/C]	$\dot{Q}$ [kW]
Cold streams						
A^1	20		80		-1.5	-90.0
B	80		140		-4.0	-240.0
Hot streams						
$C^{1,1}$	160		90		(2.5-1.07=+1.4286)	+100.0
$C^{1,2}$	90		60		+2.5	+75.0
D	150		50		+2.0	+200.0

Table 5: New list of streams after placement of heat exchanger E1

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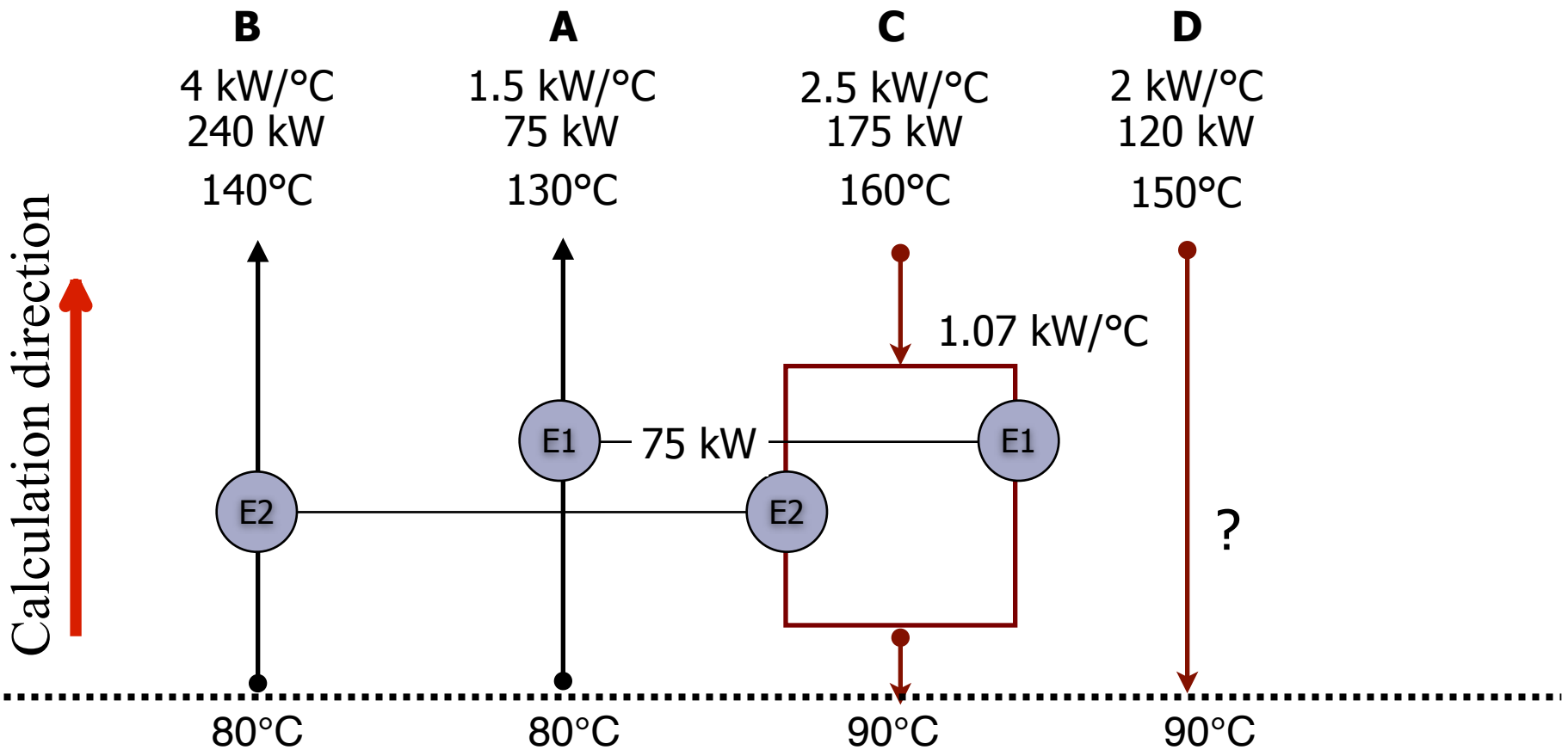
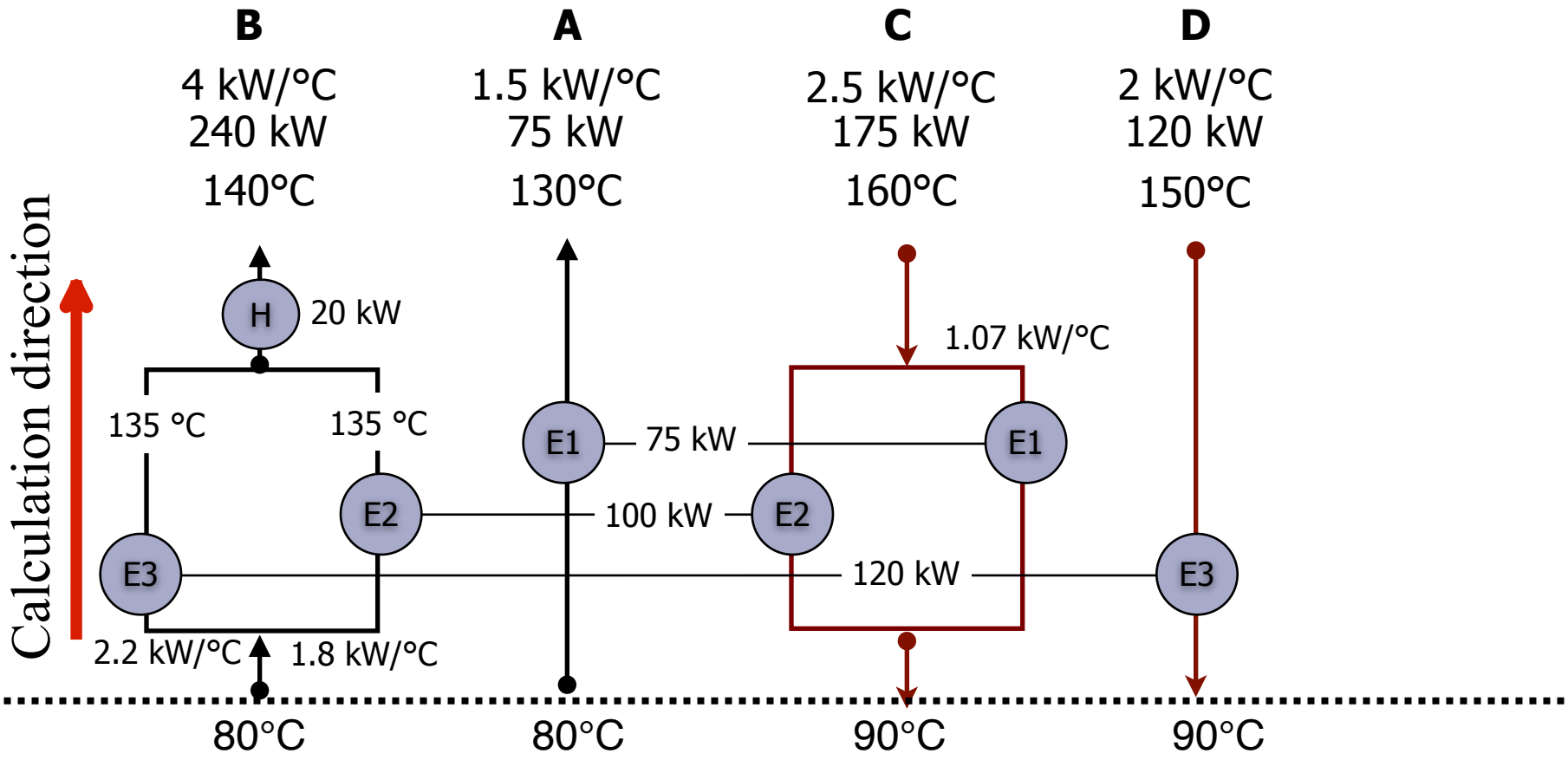
Above the pinch point : Nb of streams ?



? $N_{pinch,c} \geq N_{pinch,h}$ => Split Cold stream

Above the pinch point : Network design



Heat exchangers above the pinch

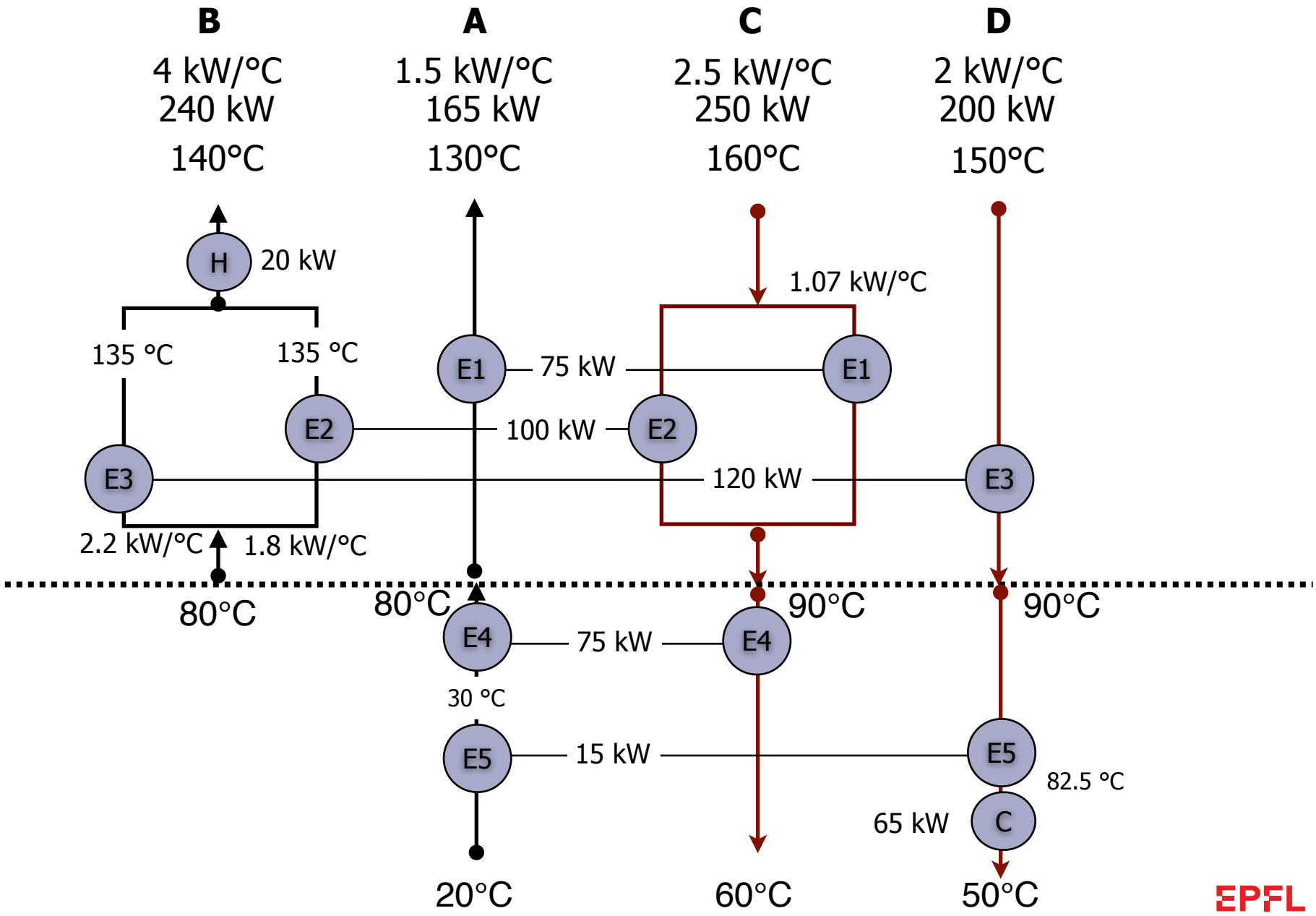
Operating cost = 2325 CHF/year

	T_{hot} [C]	ΔT_{hot} [C]	T_{cold} [C]	ΔT_{cold} [C]	ΔT_{lm} [C]	$\dot{Q}$ [kW]	A [m^2]	Cost [CHF]
E1	160 130	30	90 80	10	18.20	75.0	16.5	32945
E2	160 135	25	90 80	10	16.37	100.0	24.4	43327
E3	150 135	15	90 80	10	12.33	120.0	38.9	60055

Investment : [CHF] : $4630(A)^{0.7}$

Fluid heat transfer coefficient U = 0.5 kW/C°/m2

Below the pinch point : Network design



Heat exchangers after Pinch design method

Operating cost = 2325 CHF/year

	T_{hot} [C]	ΔT_{hot} [C]	T_{cold} [C]	ΔT_{cold} [C]	ΔT_{lm} [C]	$\dot{Q}$ [kW]	A [m^2]	Cost [CHF]
E1	160 130	30	90 80	10	18.20	75.0	16.5	32945
E2	160 135	25	90 80	10	16.37	100.0	24.4	43327
E3	150 135	15	90 80	10	12.33	120.0	38.9	60055
E4	90 80	10	60 30	30	18.20	75.0	16.5	32947
E5	90 30	43.3	82.5 20	62.5	61.24	15.0	1.0	4630
Total						385.0	97.3	173905

Table 7: Heat Exchangers obtained with Pinch Design Method

Fluid heat transfer coefficient U = 0.5 kW/C°/m2

Investment : [CHF] : $4630(A)^{0.7}$

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Conclusions

- Systematic method for heat exchanger network design
  - Start from the pinch
    - Goals with respect to pinch location
  - Feasibility rules to select streams
  - Split if necessary
  - Heat load by tick-off rule (minimum number of units)
  - Heat exchanger network calculation
    - from the pinch !