Process integration

Penalising heat exchangers

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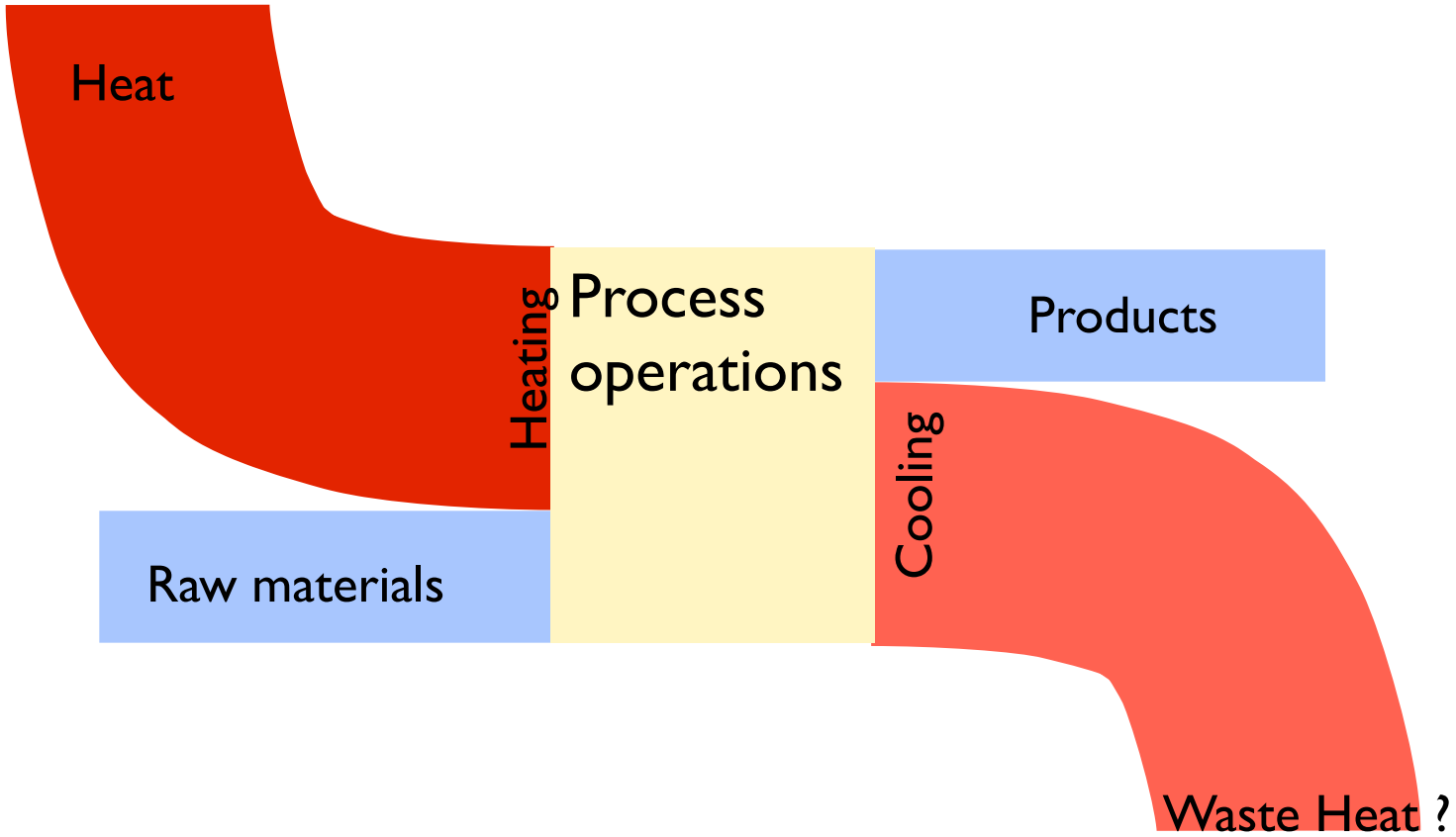
- The More-in The More-out

The more In / The more Out



By energy balance, the energy entering the system is leaving the system, if it does not leave in the product it has to leave as the cold utility

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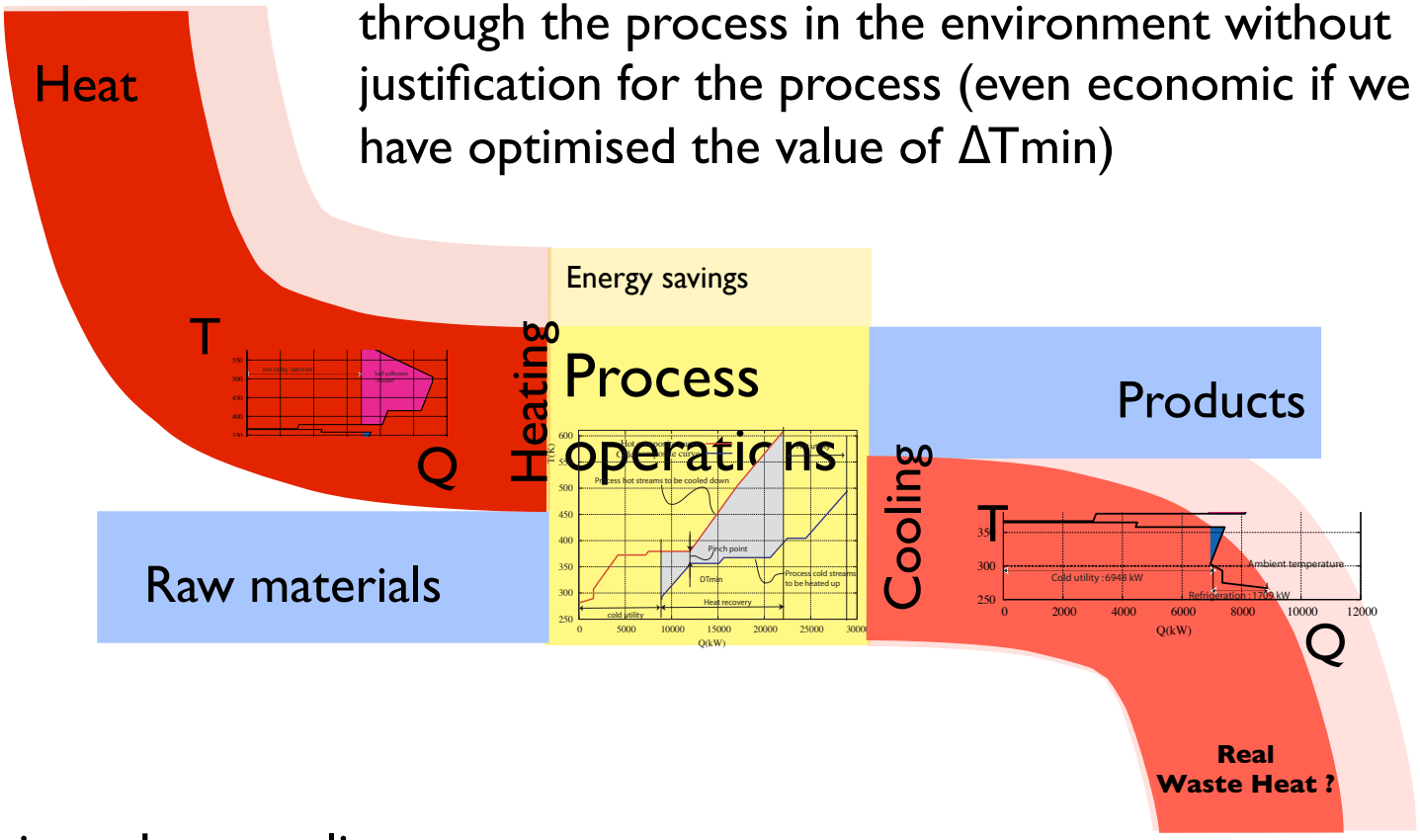
Energy Usage : The more in / The More Out

The energy saving is the amount of heat that flows through the process in the environment without justification for the process (even economic if we have optimised the value of ΔTmin)



Less Heating = Less cooling

By energy balance, the reduction in the heat requirement corresponds to a reduction of the heat released by the process and to be evacuated by a cold utility. Heat recovery leads therefore to savings in the hot utility and by energy balance to the reduction of the waste heat of the process that is released to the environment by the hot utility.

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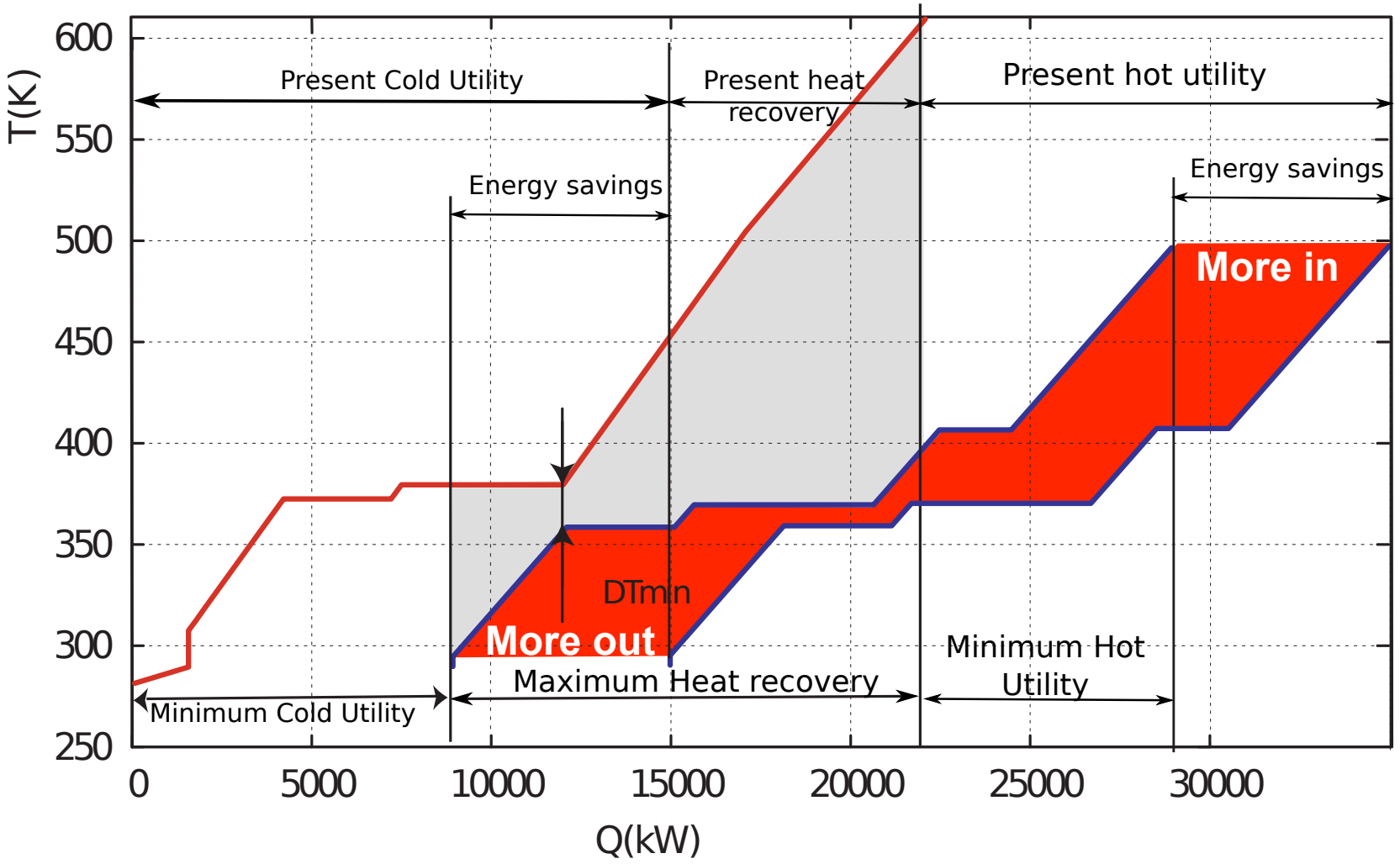
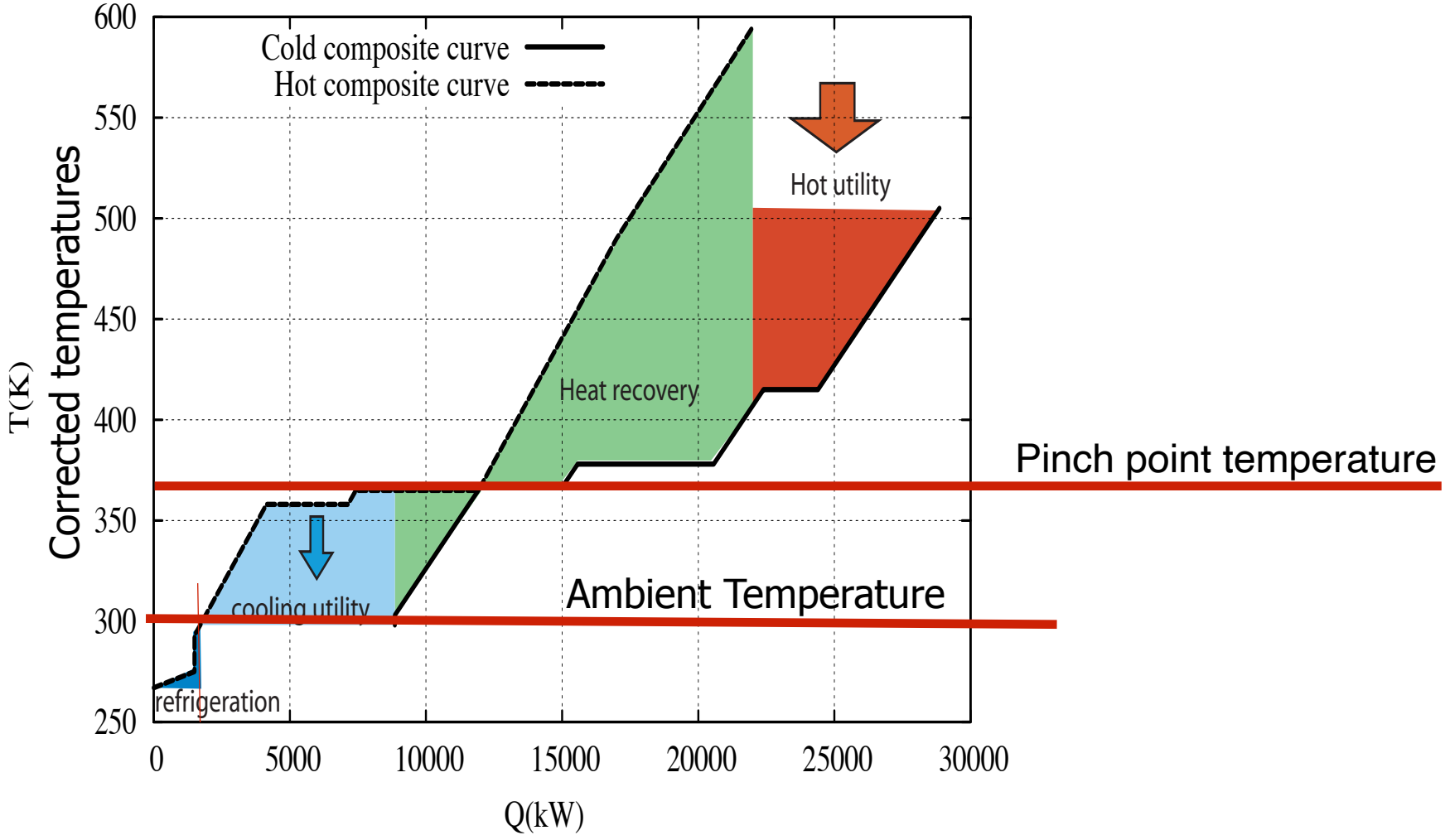
The More-in More-out Principle



Saving of hot utility = Saving of cold utility

Savings of hot utility = Amount of heat that you buy today to heat the environment

3 Independent sub-systems



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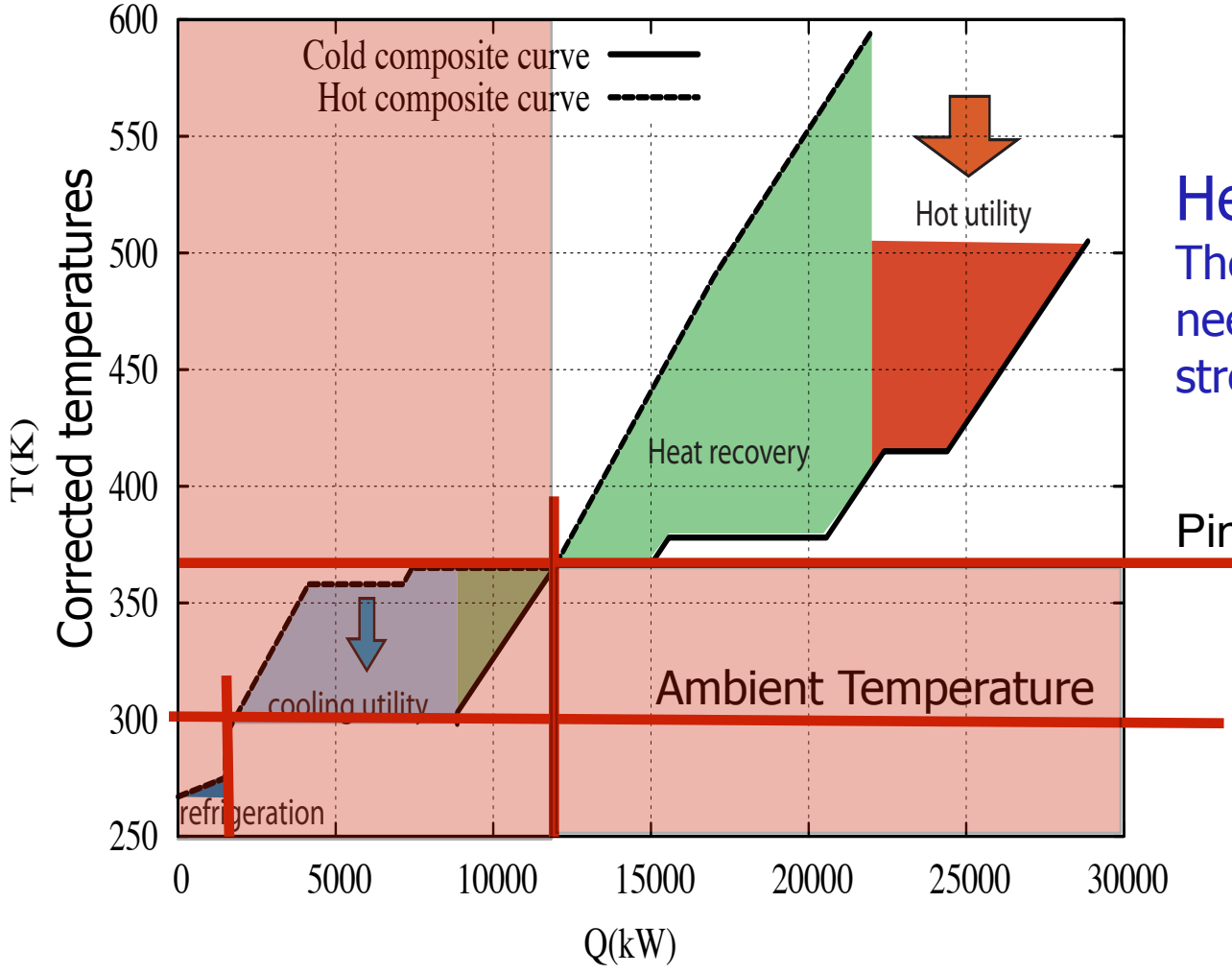
3 Independent sub-systems

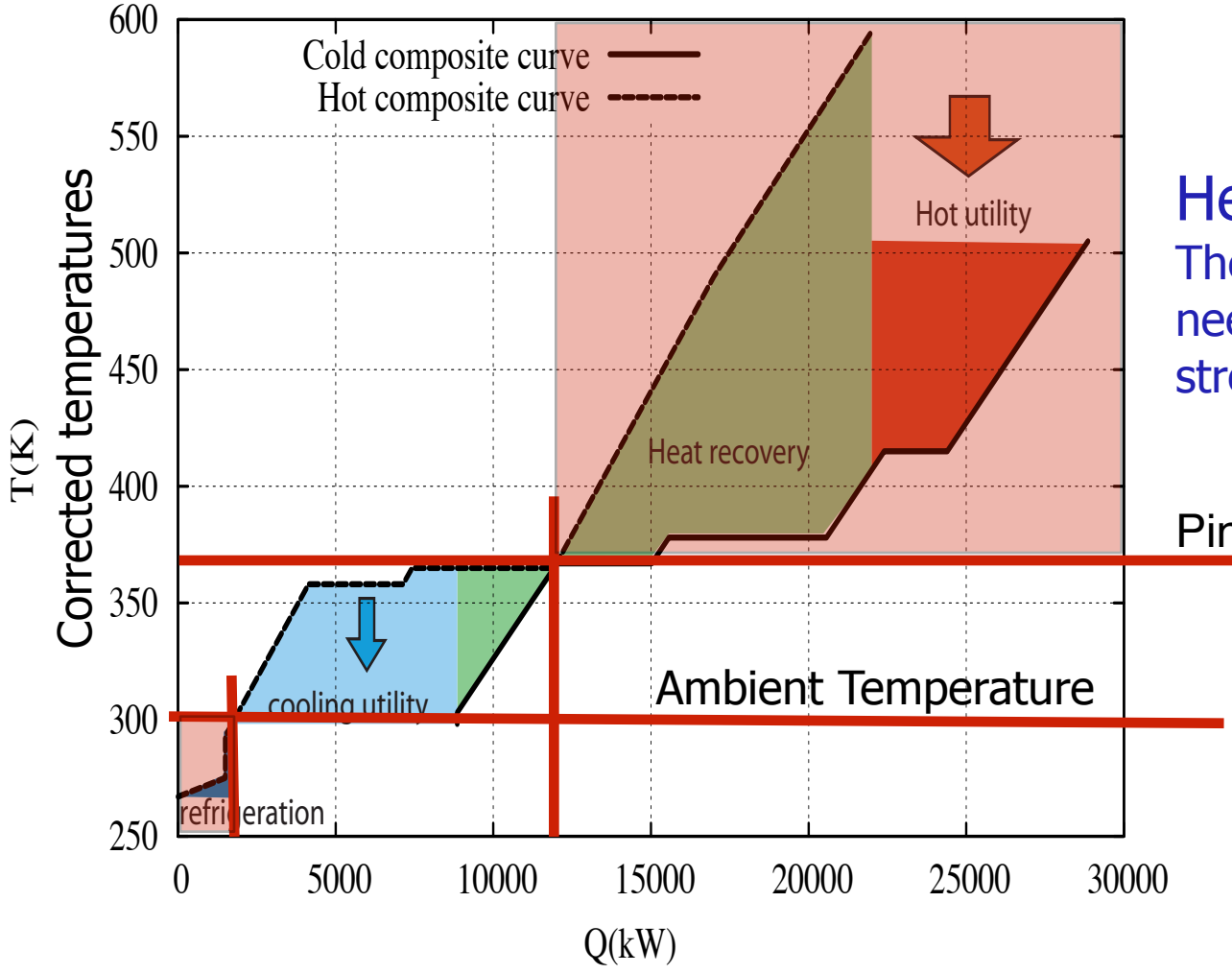


Heat sink

The heat of hot streams is needed to preheat the cold streams above the pinch

Pinch point temperature

3 Independent sub-systems



Heat sink

The heat of hot streams is needed to preheat the cold streams above the pinch

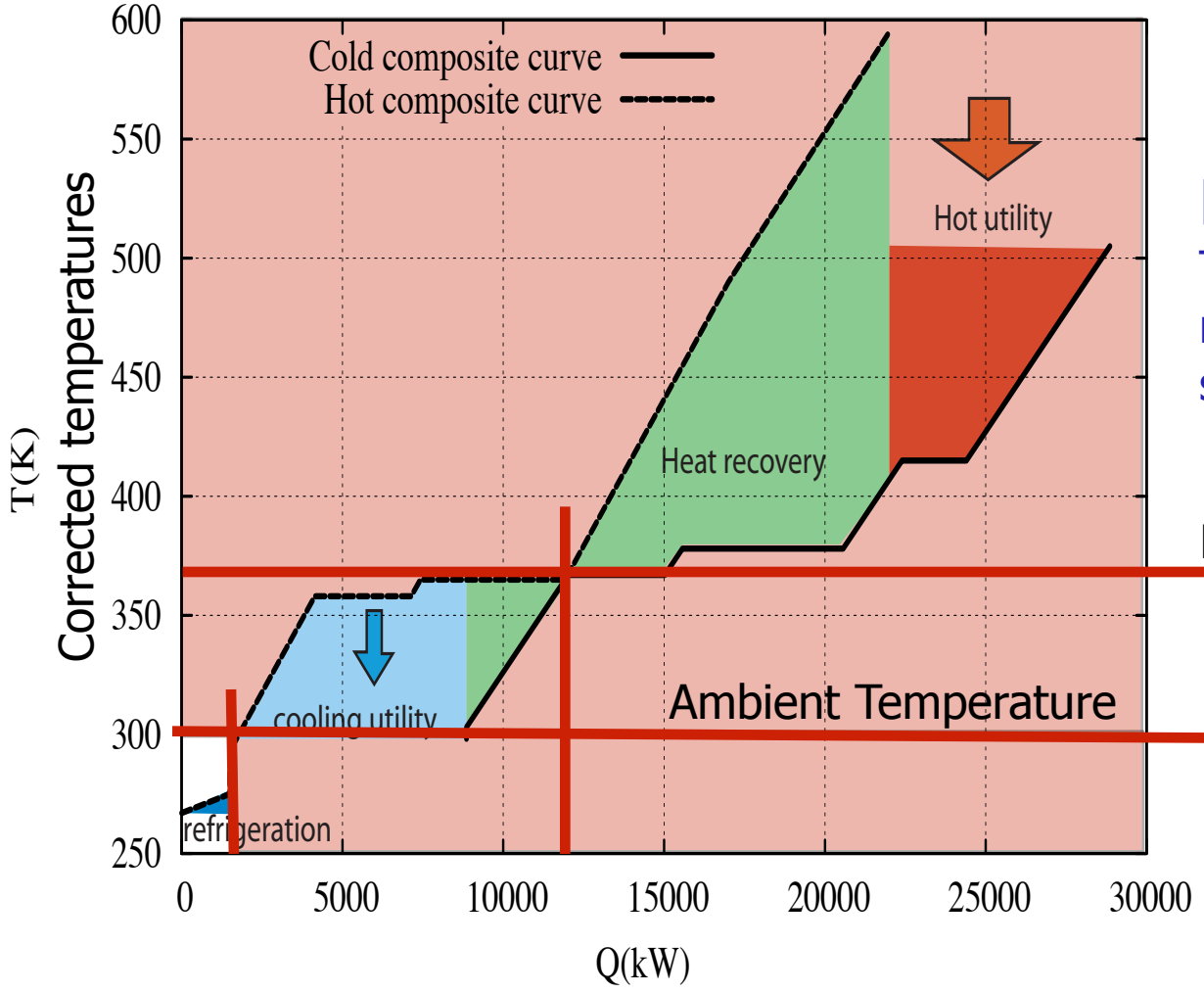
Pinch point temperature

Heat source

The heat to the cold streams is supplied by the hot streams below the pinch

The ambient temperature is important because below the ambient temperature, cooling means refrigeration and therefore needs a device to heat from below the ambient temperature to release the heat in the environment

3 Independent sub-systems



Heat sink

The heat of hot streams is needed to preheat the cold streams above the pinch

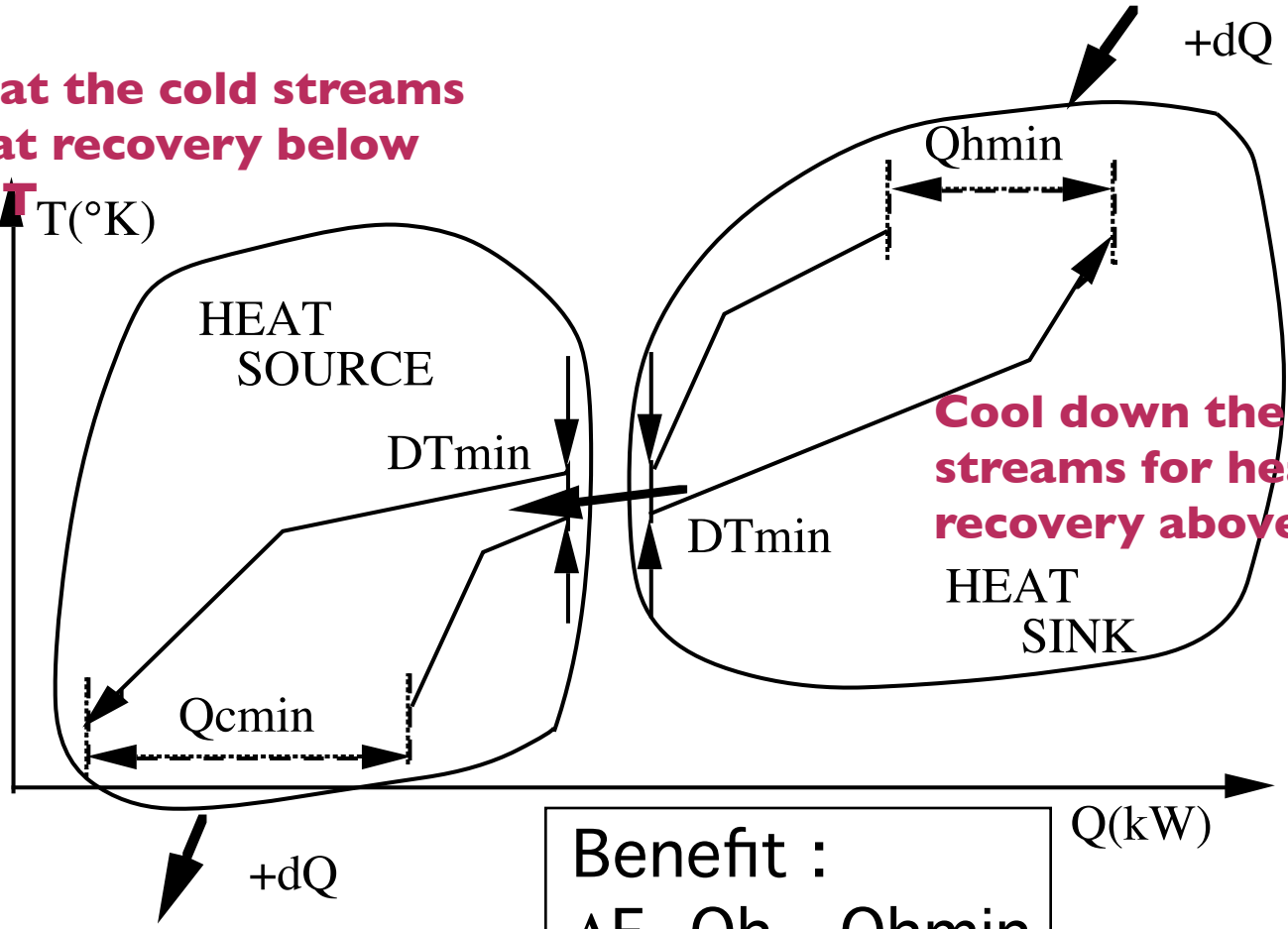
Pinch point temperature

Heat source
The cold streams are heated by the hot streams

Heat source
below ambient temperature
REFRIGERATION
The cold streams can supply refrigeration by heat recovery

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

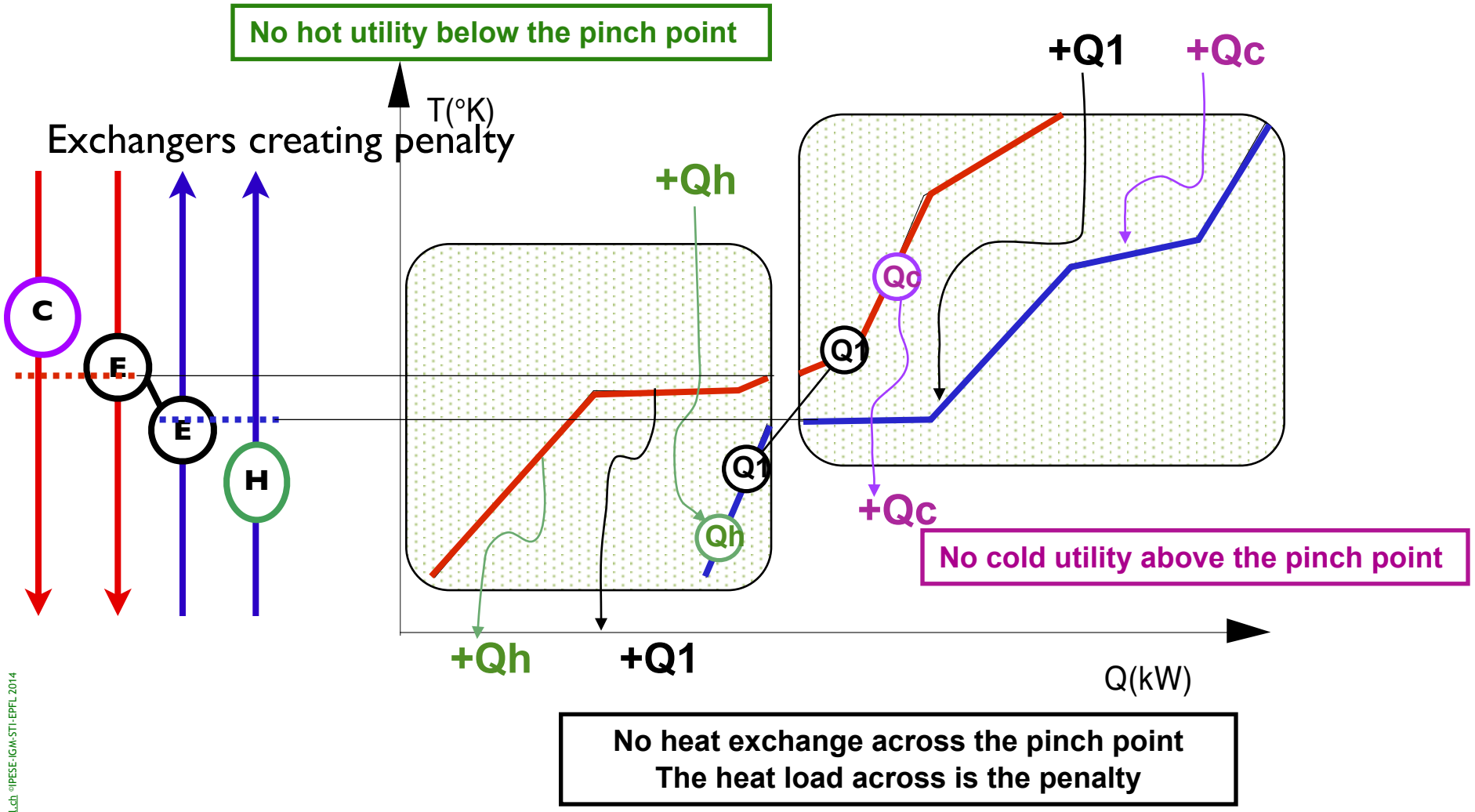
Benefit :

$\Delta E = Qh - Qhmin$

$\Delta E = Qc - Qcmin$

QH-QC = Constant !

Penalizing heat exchangers



There are 3 types of penalising heat exchanges

1. a cold utility is used to cool a hot stream above the pinch. Above the pinch, this heat has to be used for heat recovery. One has to identify a cold stream above the pinch to cool the identified hot stream.
2. a hot utility that is used below the pinch. Below the pinch there is enough heat in the hot stream to preheat all the cold stream with a hot utility. One has to identify the hot stream below the pinch to supply the heat to the cold stream so that it reaches the pinch temperature.
3. a heat exchanger that is preheating a cold stream below the pinch with a hot stream above the pinch. The heat of the hot stream is indeed needed to preheat a cold stream above the pinch. In such a case, one has to identify a cold stream above the pinch to cool down the hot stream above the pinch and to identify a hot stream below the pinch to preheat the cold stream below the pinch

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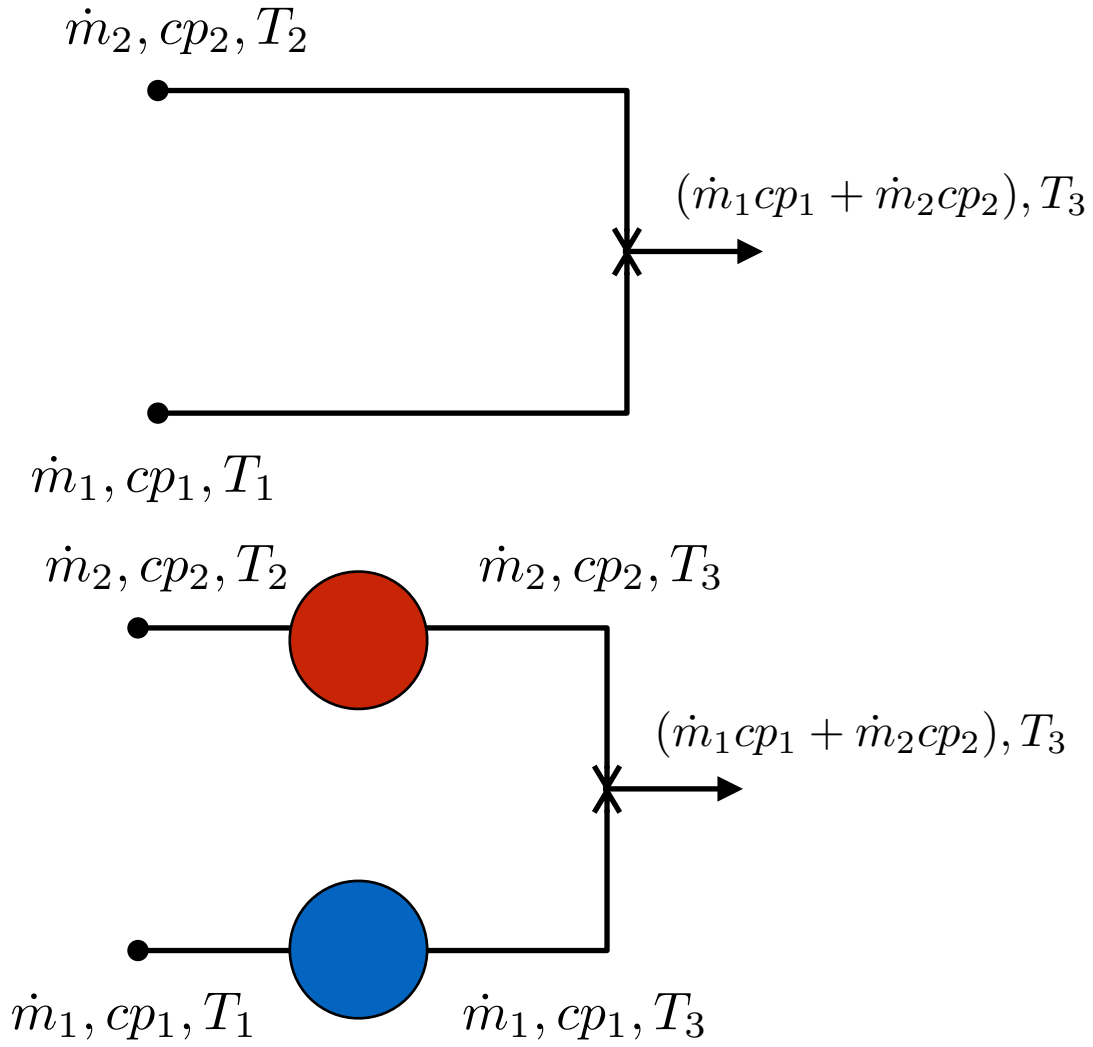
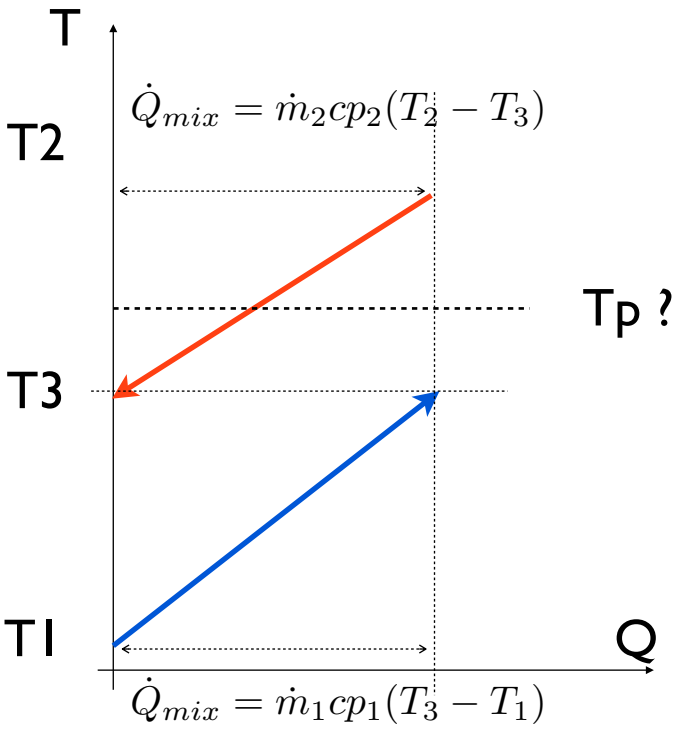
Mixing unit is a heat exchanger





Mixer are hidden heat exchangers, when well positioned (all temperatures above or below the pinch) they are cheap heat exchangers. When one of the 3 temperatures is on the other side of a pinch, the mixer is penalising. In the example above the heat of the hot stream above the pinch Tp is needed to heat a cold stream above the pinch. After the heat recovery it can be send to the mixer with the cold stream that should have been preheated by a hot stream below the pinch.

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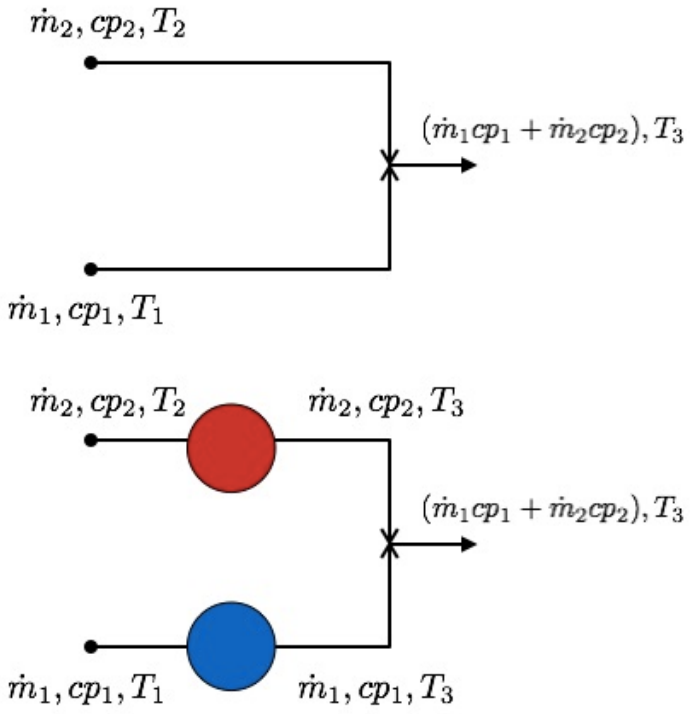
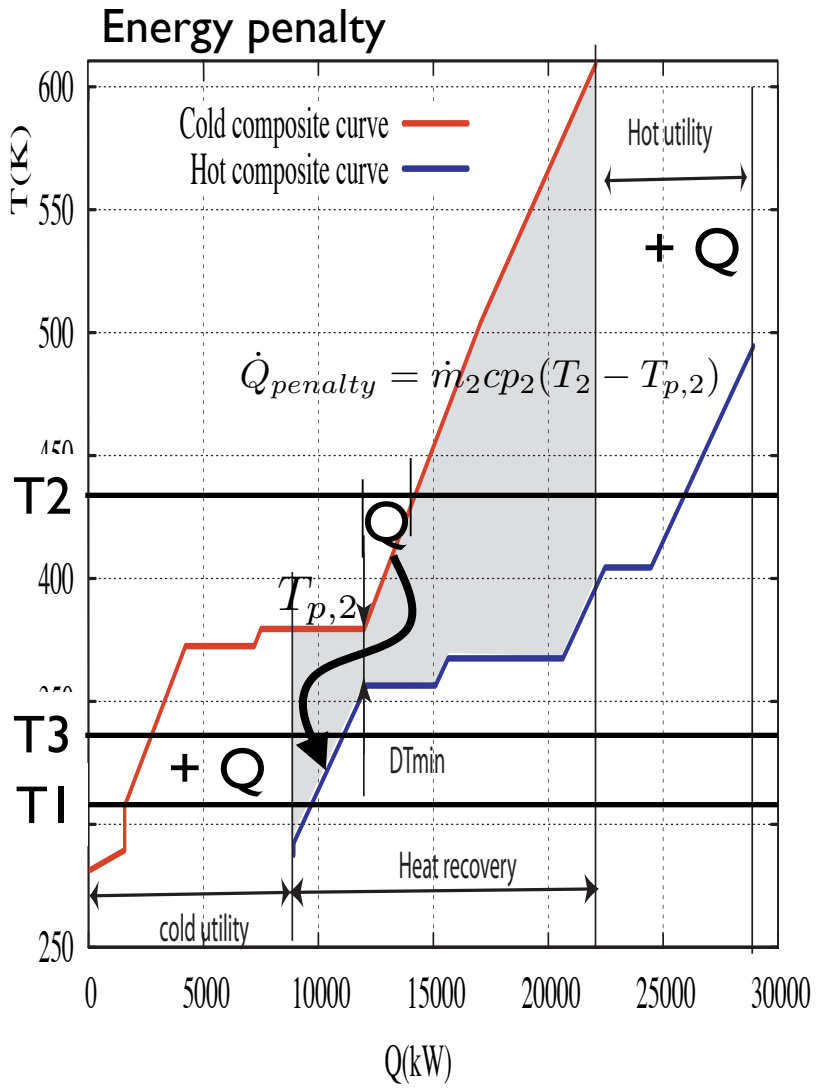
Penalizing mixing unit

- Mixing





The penalty is the heat load above the pinch, it is needed to identify both the new exchange above the pinch to recover the heat to preheat the cold stream AND the heat recovery to preheat the cold stream below the pinch.