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DUAL REPRESENTATION OF MINIMUM ENERGY REQUIREMENTS APPLICATIONS TO P&P PROCESSES

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Highlights

Minimum energy requirement (MER)

- Integrated process-energy system
- Pinch analysis & MER
- Dual representation

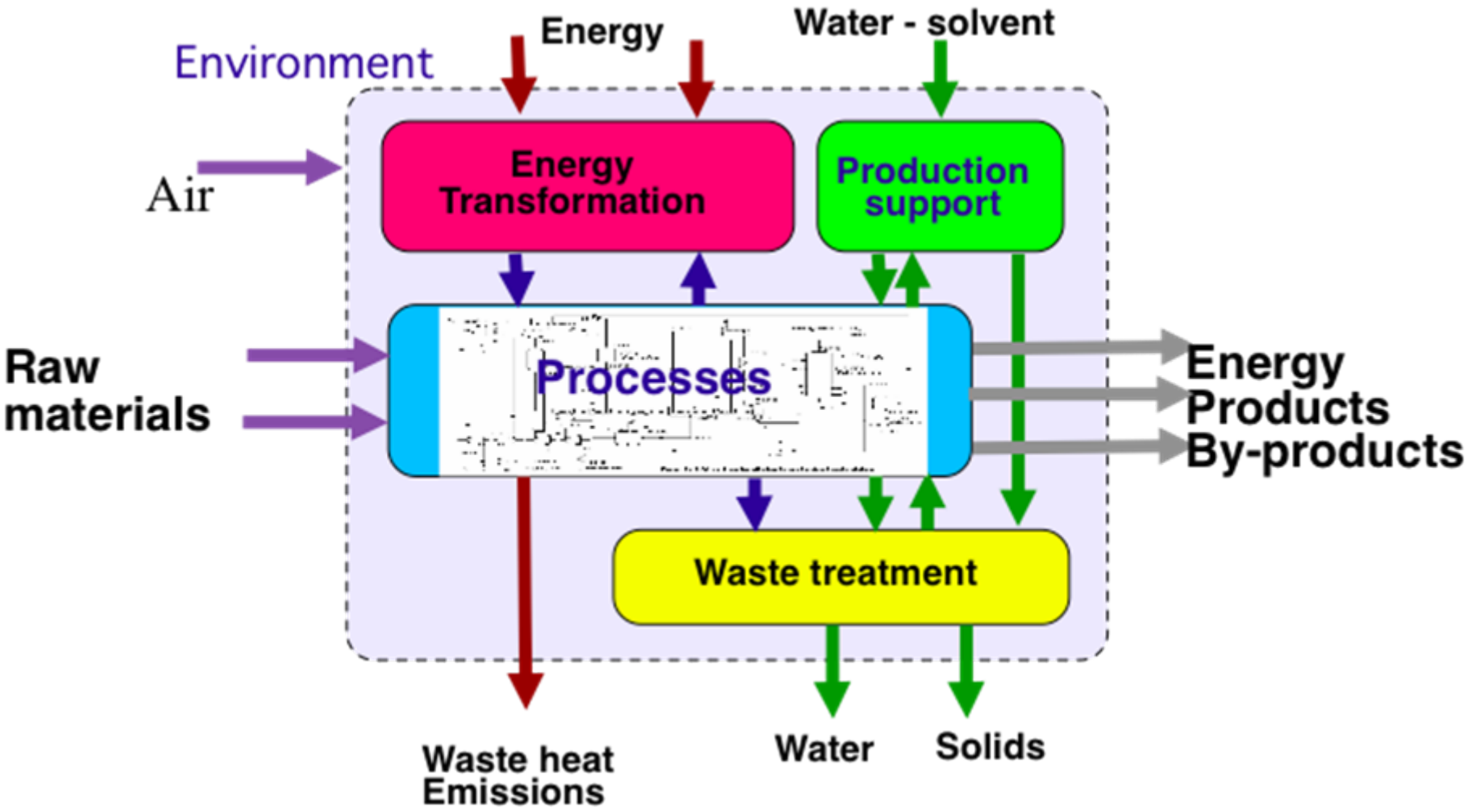
Application to P&P operations

- Heating of a process stream
- Dilution and heating
- Paper machine drying section

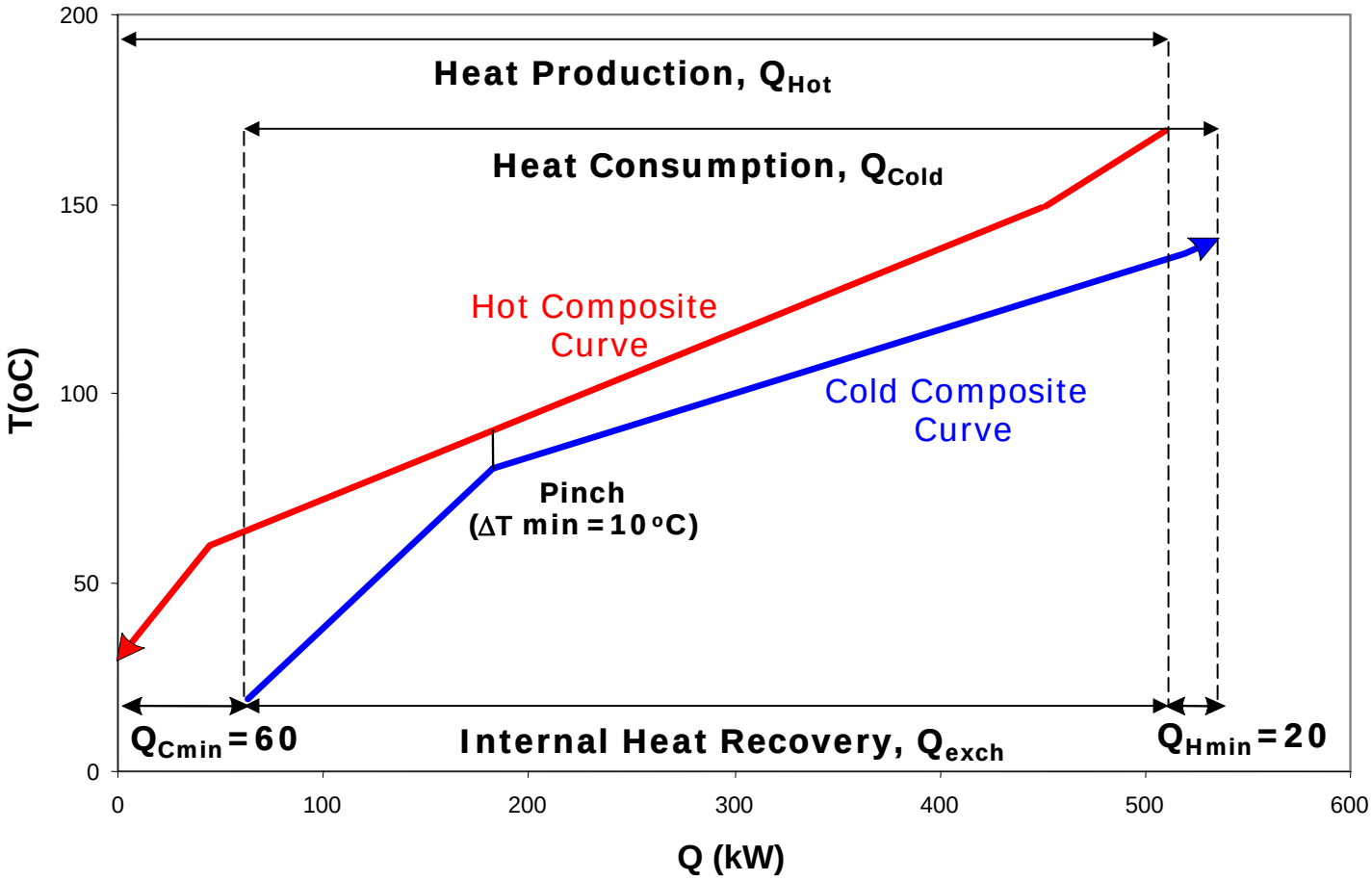
Illustration : Integrated TMP-Newsprint Mill

Concluding remarks

Integrated Process-Energy System



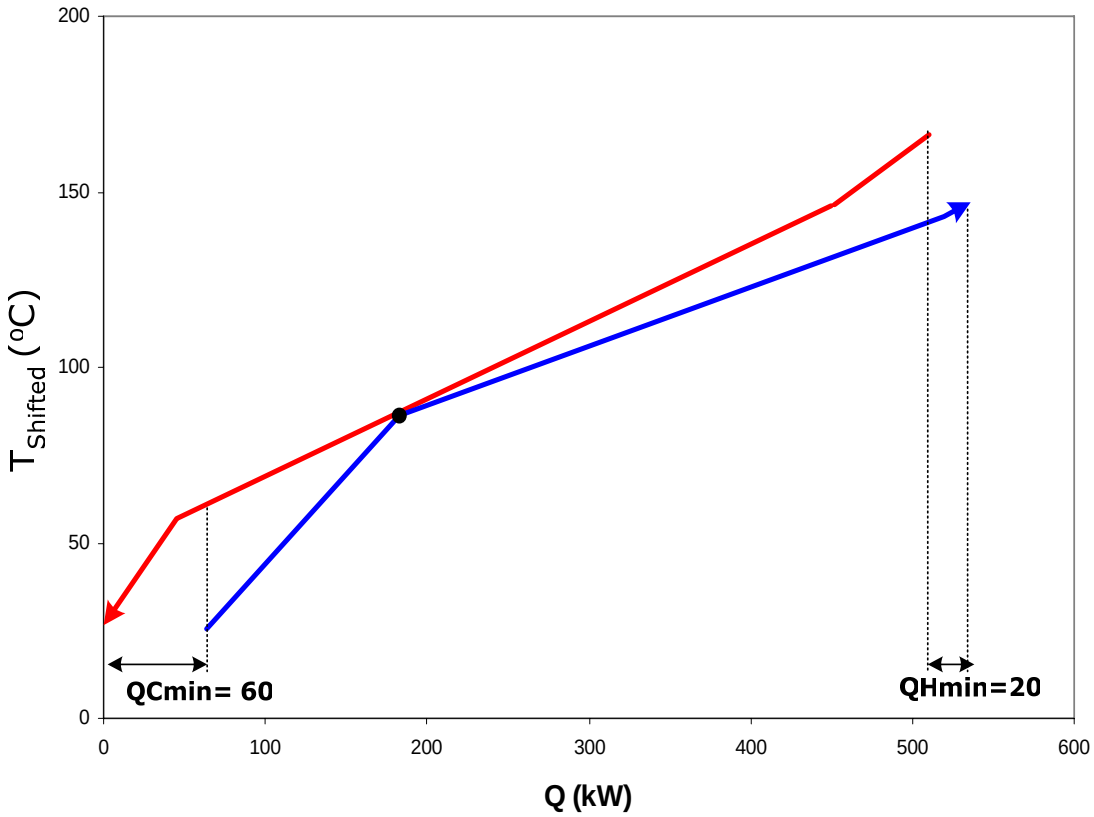
Minimum Energy Requirement : Process Side



MER = Q_{Hmin}

$$Q_{Cmin} = Q_{Hot} + Q_{Hmin} + Q_{Cold}$$

Process MER and Grand Composite Curve Shifted Temperatures



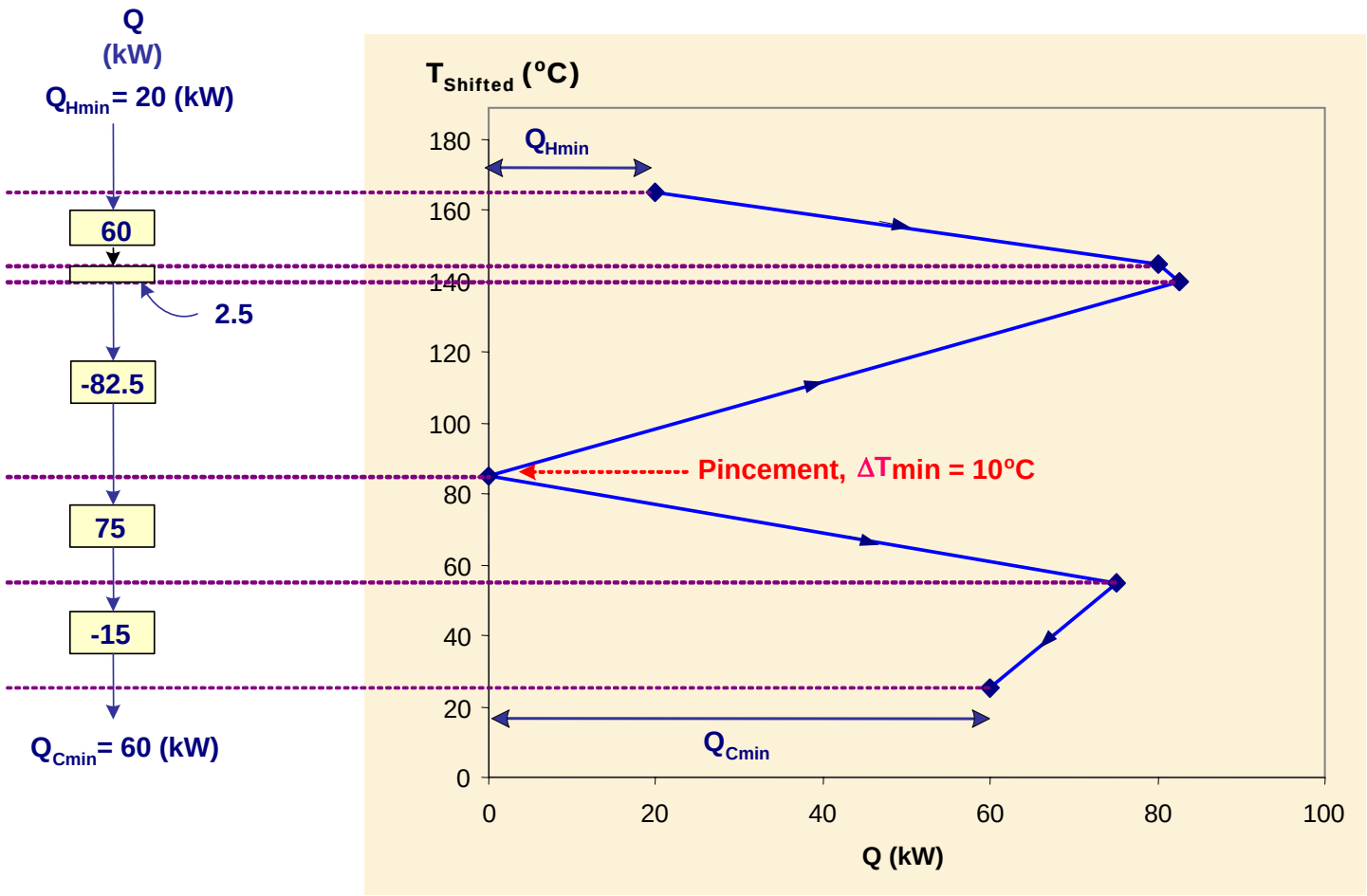
Hot streams : $T_f = T_i - \Delta T_{min/2}$

Cold streams : $T_f = T_i + \Delta T_{min/2}$

Table of temperatures

Actual (°C) IN/OUT	Shifted (°C) IN/OUT	Cp (kW/°C)
170/60	165/55	3
150/30	145/25	1.5
20/135	25/140	2
80/140	85/145	4

Process MER and Grand Composite Curve Diagram Construction

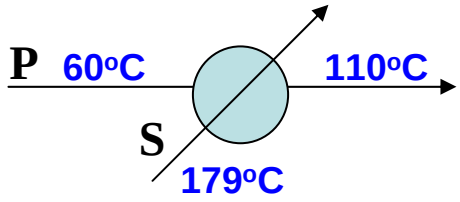


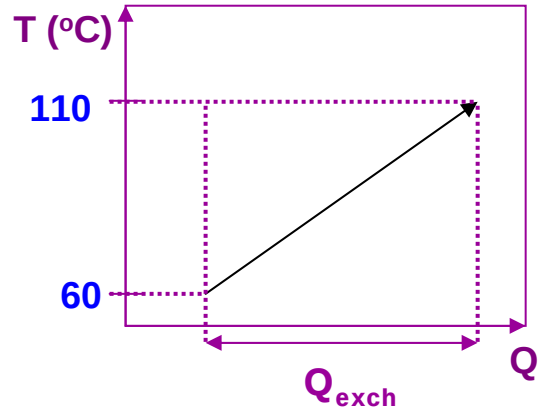
Dual Representation:

Energy Requirement and its Technical Implementations

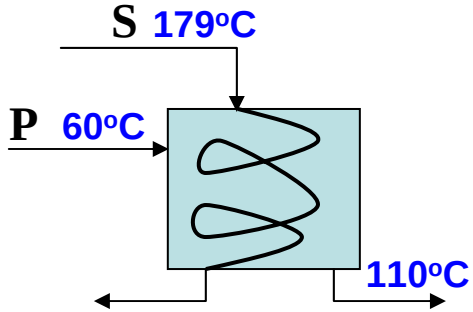
Cold Stream Definition for One Demand

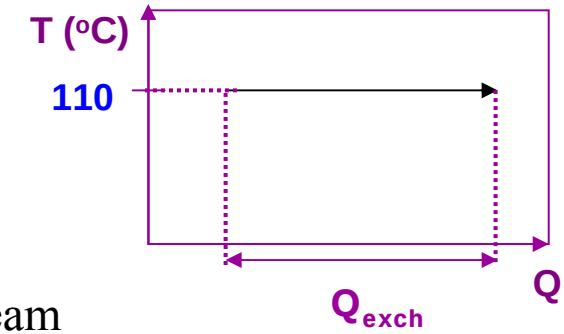
Heat Exchanger





Reservoir Heater (CST model)



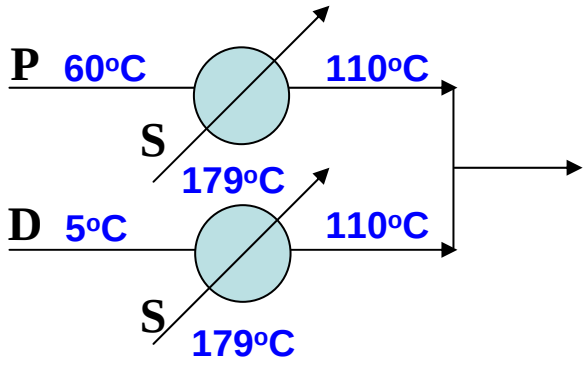


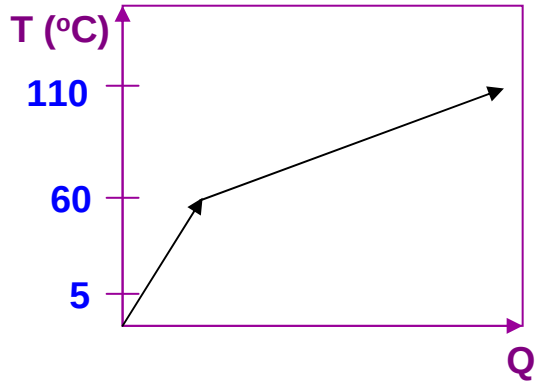
P: process stream, **D**: dilution, **S**: steam

MER = Q_{exch}, determined from demand on utility

P&P Application 1 : Dilution and heating

Heat Exchanger





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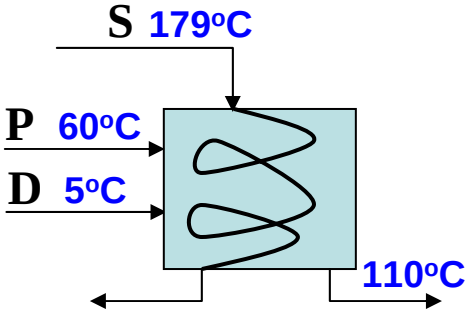
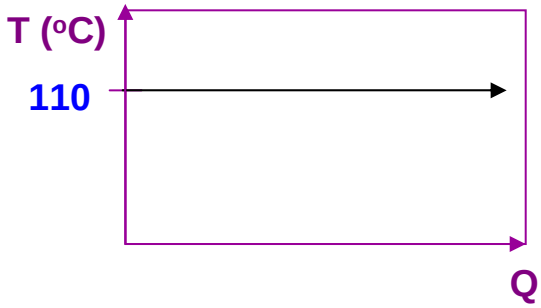
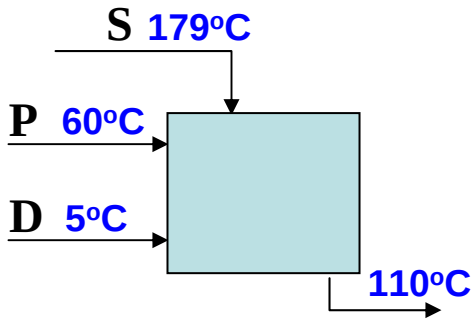
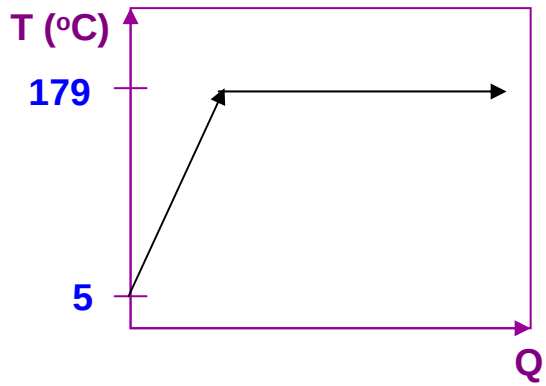




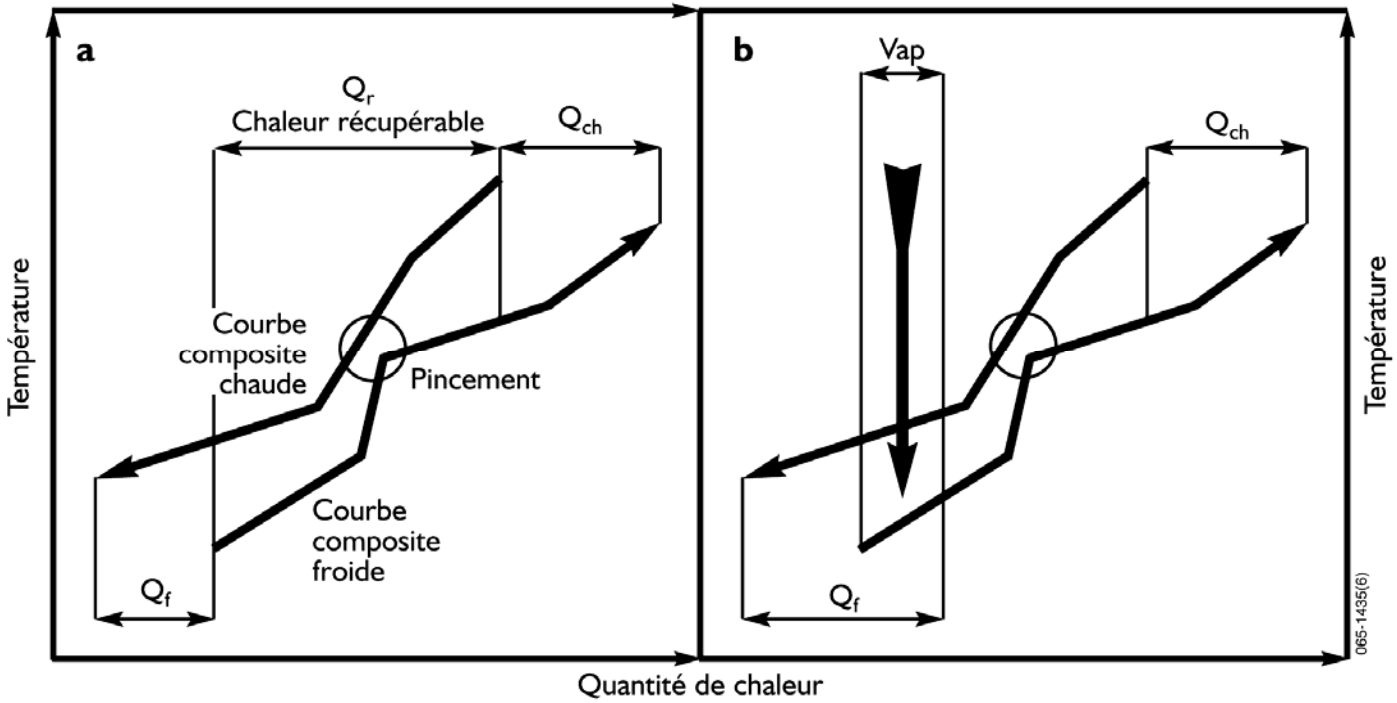
Steam Injection





P: process stream, **D**: dilution, **S**: steam

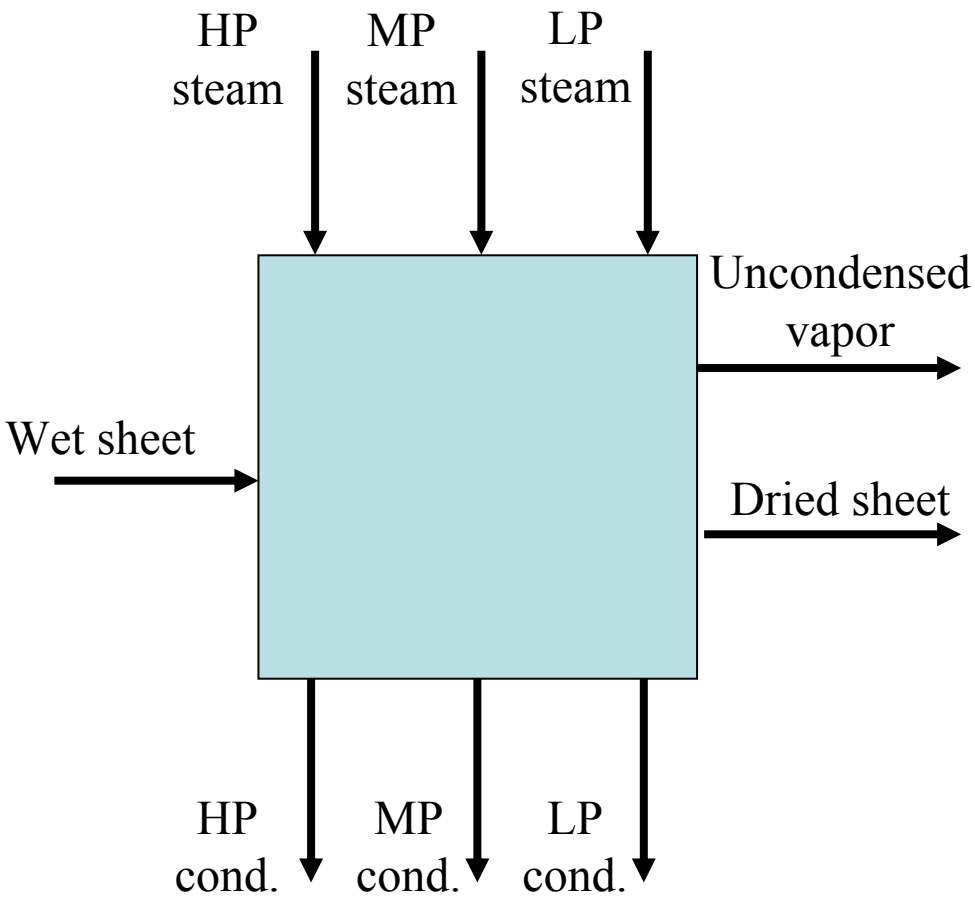
Heating by steam injection : The pinch point pitfall



Steam should not be used below the pinch point

- This does not result in any net energy savings
- The effect is: the more in, the more out

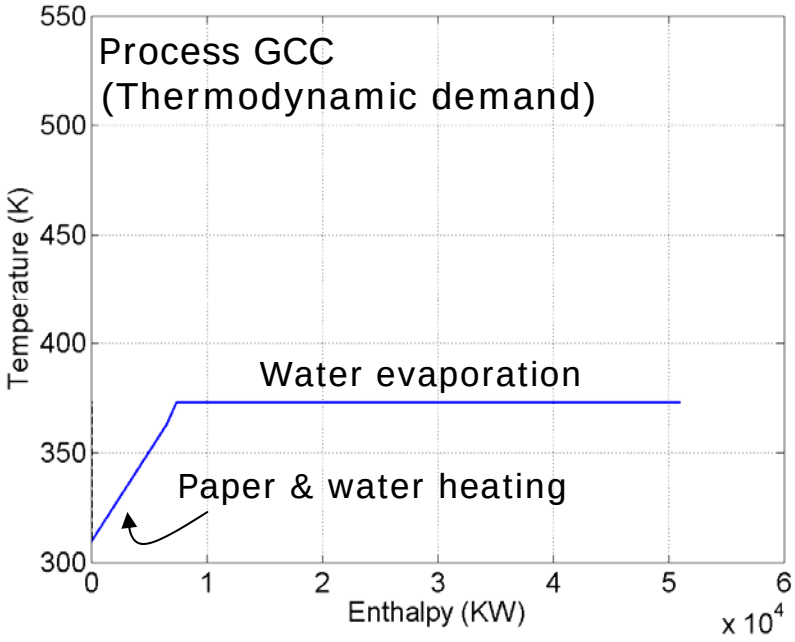
P&P Application 2 : PM Drying section

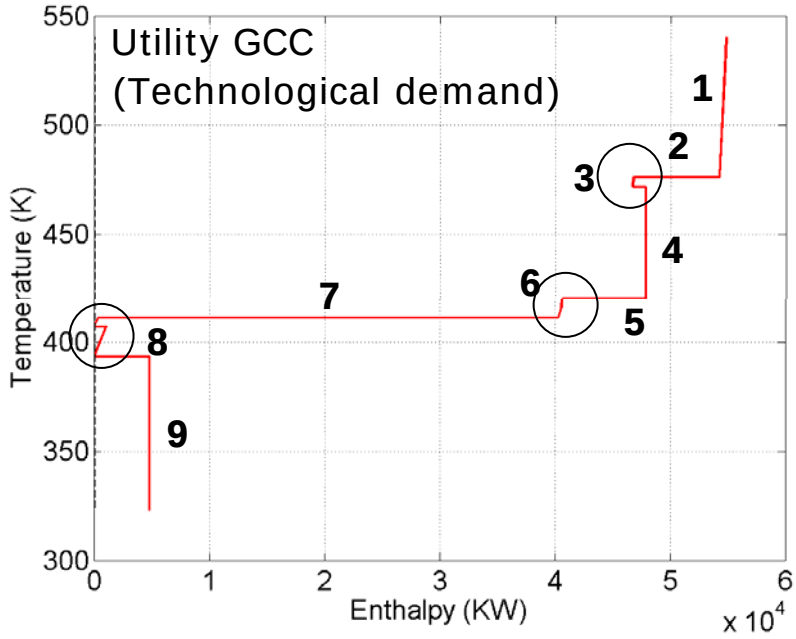


Stream Table

Stream	P (kPa)	T (° C)	m (t/h)
HP	1650	267	69
HP cond.	1510	199	69
MP	445	148	12
MP cond.	305	134	12
LP	340	143	14
LP cond.	200	121	14

PM Drying Section : Process and Utility Representations

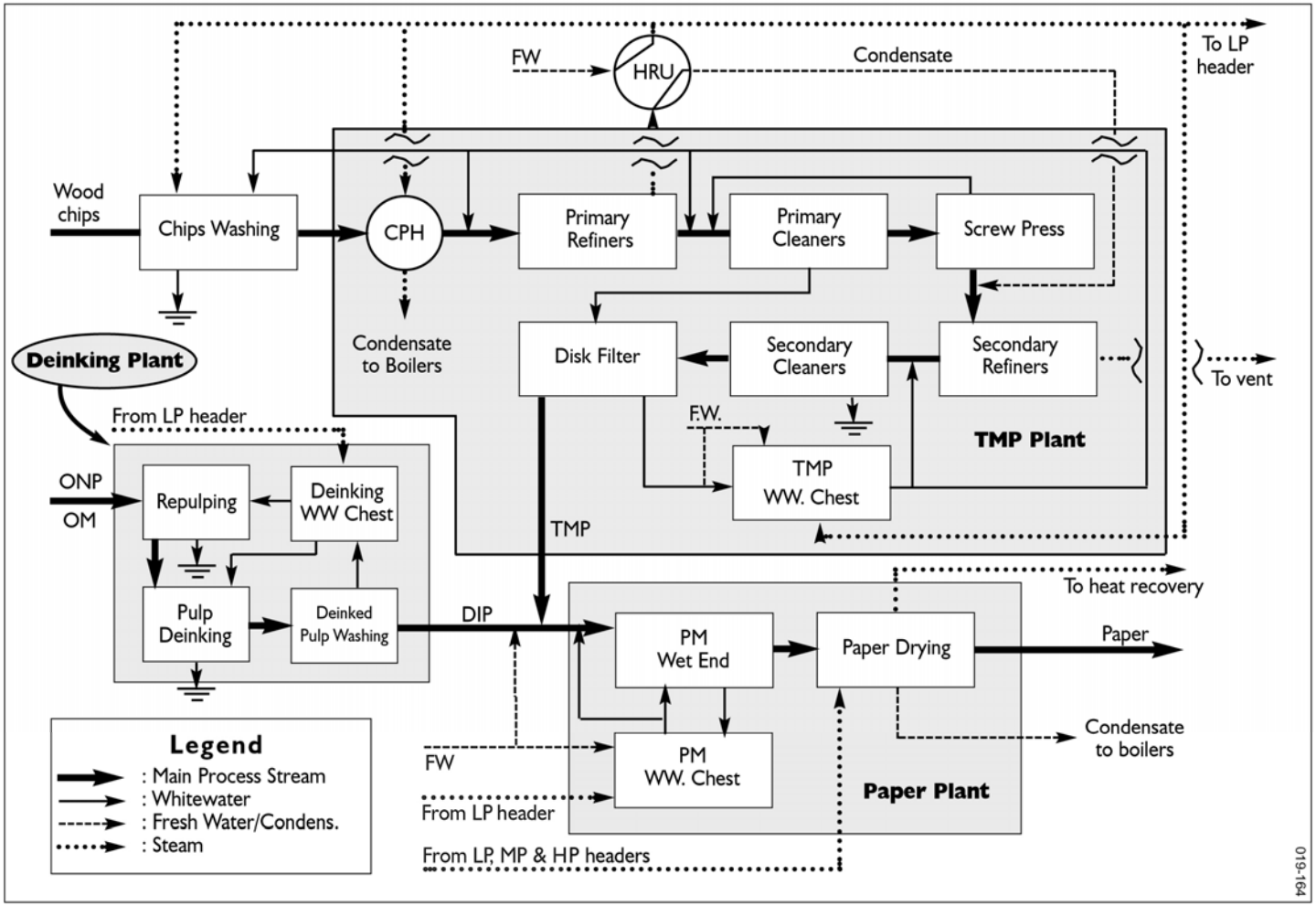




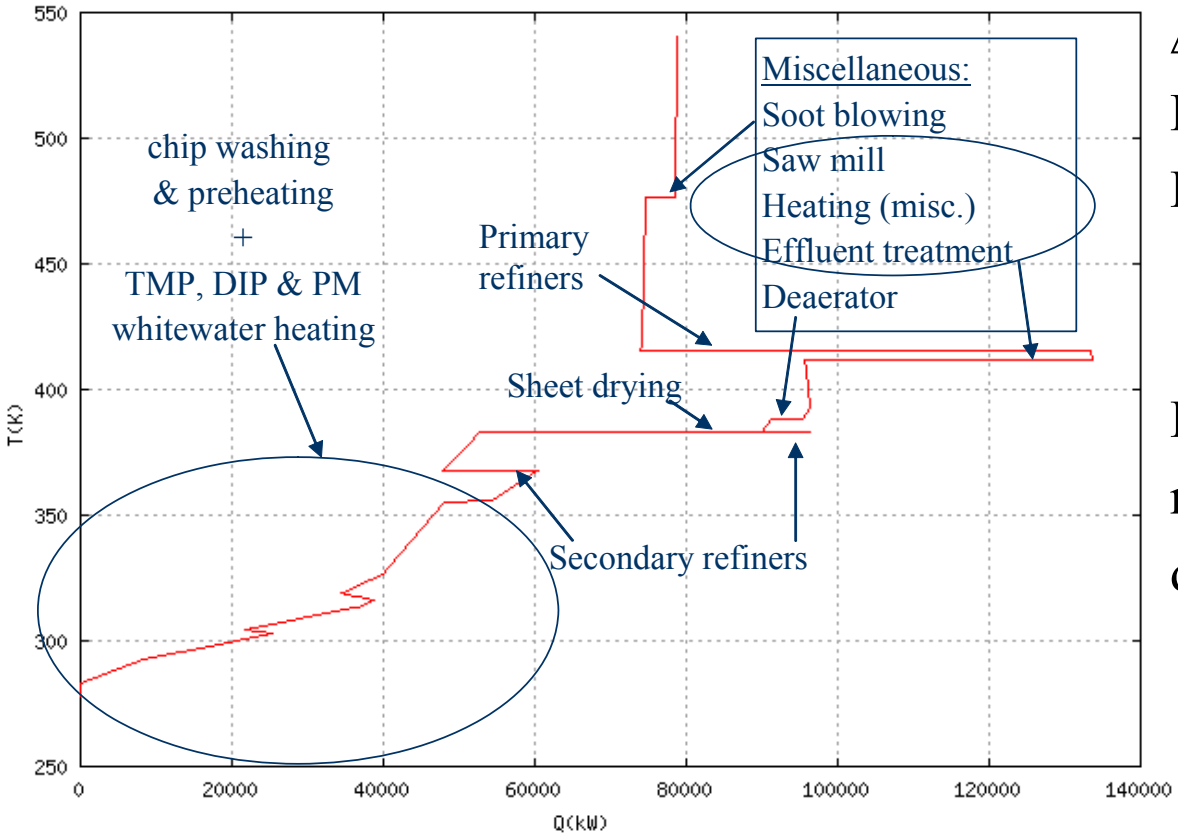
① HPS superheating
② Production of HPS
③ HPS post condensation
④ Exchange between HP water preheating and HP condensate

⑤ Production of MPS
⑥ Exchange between HP & MP water preheating and HP condensate
⑦ Production of LPS
⑧ MHS and LPS post condensation
⑨ Condensate reheating

Illustration : Integrated TMP-Newsprint Mill



Thermodynamic MER



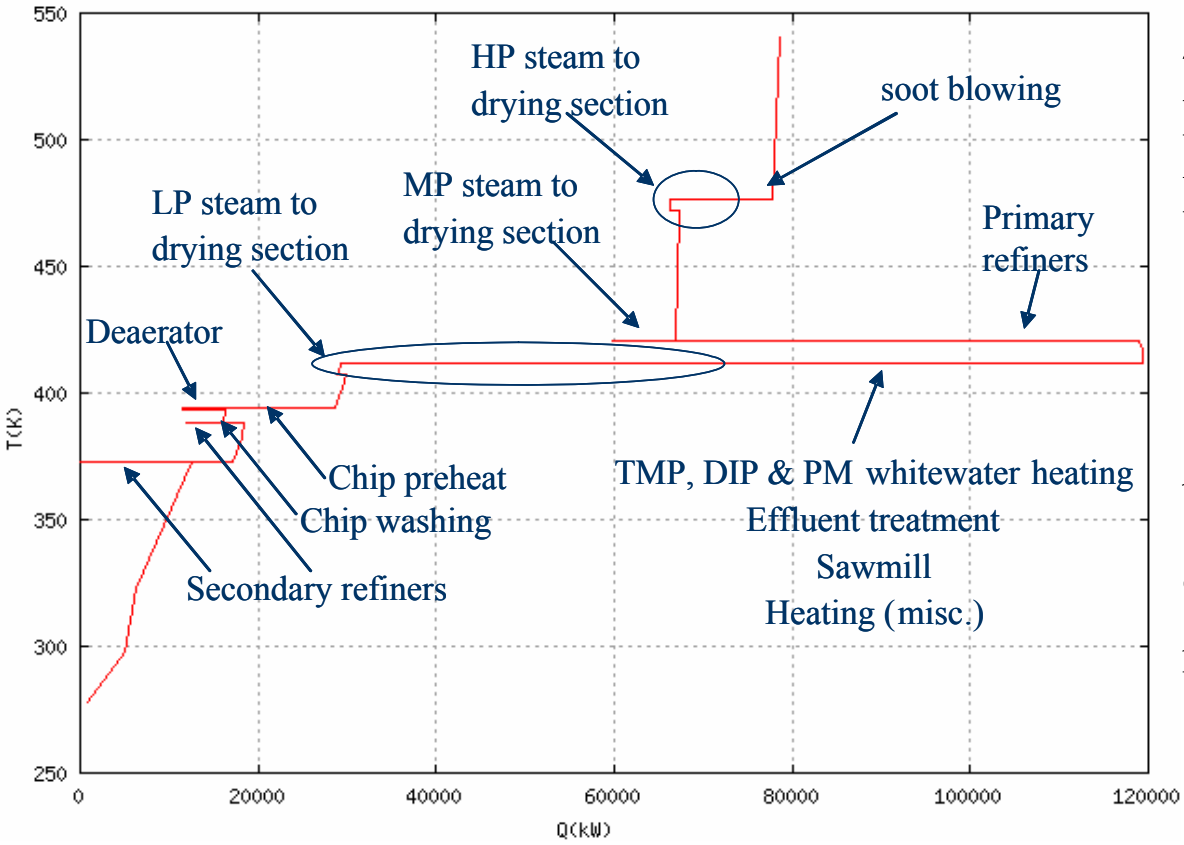
ΔT_{min} = 10 K

Pinch point (threshold) at 283 K

Process MER = 79 MW

Diagram implies maximum heat recovery; HX network to be defined

Technological MER



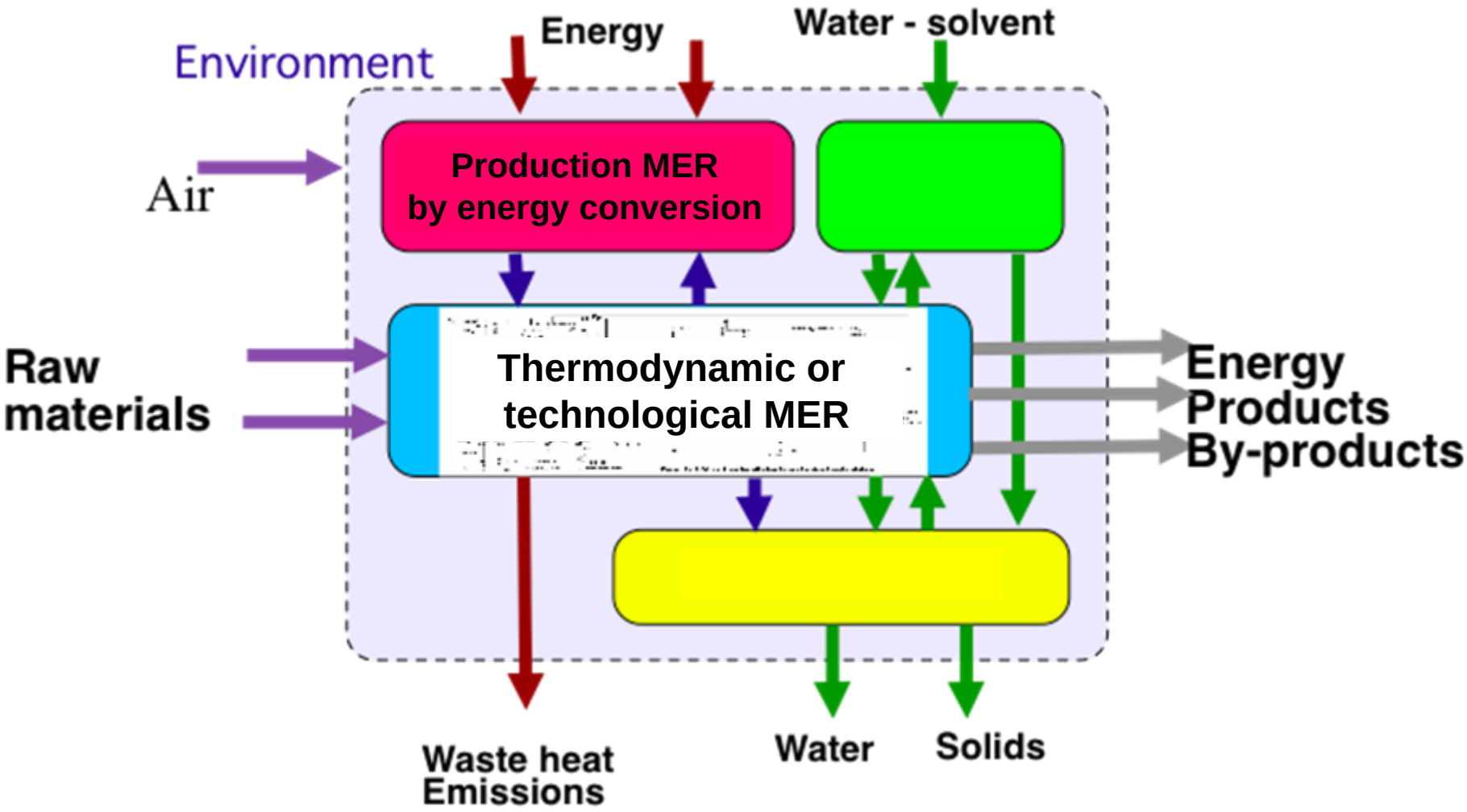
ΔT_{min} = 10 K

Pinch point at 373 K

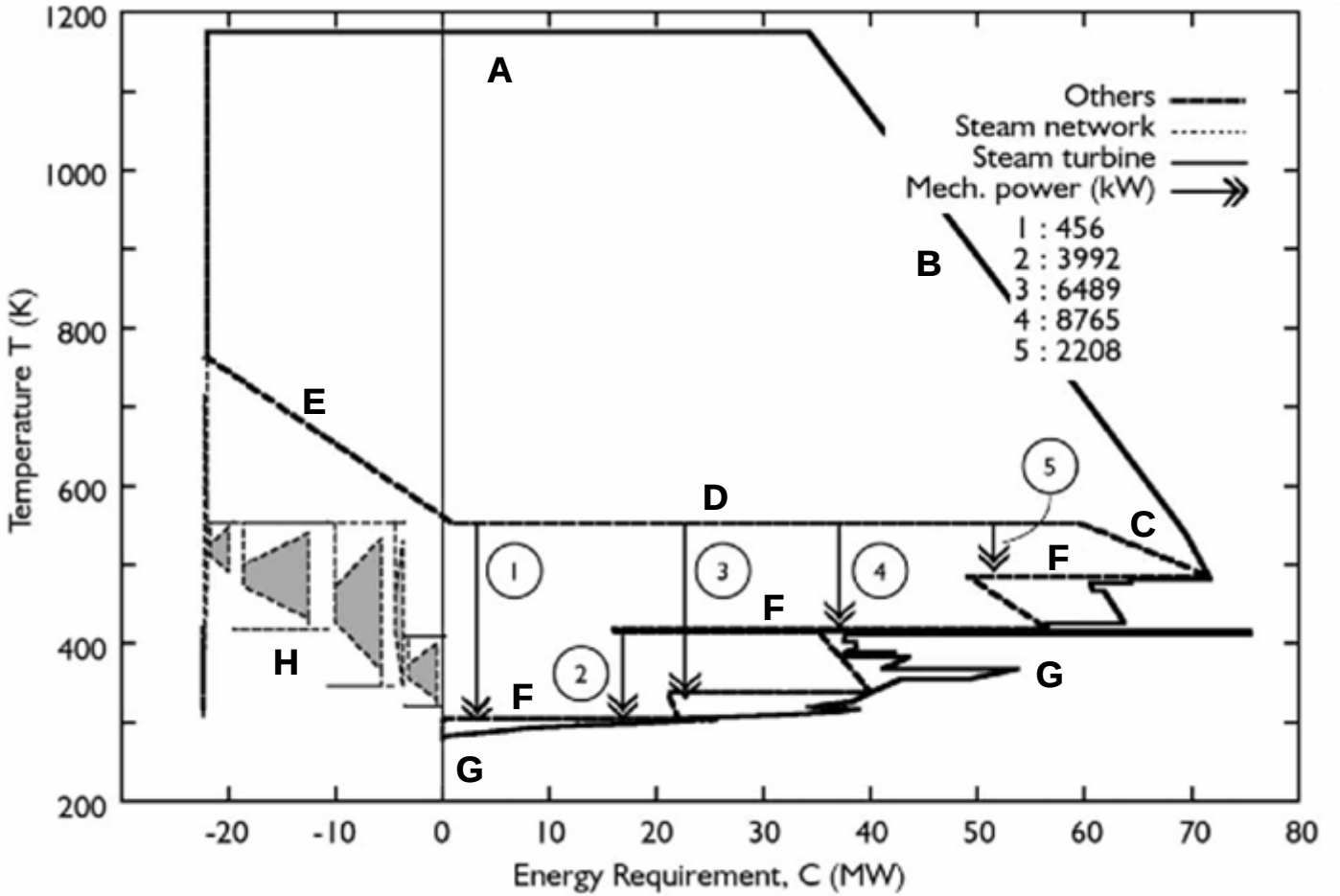
Process MER = 79 MW

System integration represented by the two GCCs are different, corresponding heat recovery network will be different

Integrated Process-Energy System



MER Production by Energy Conversion



Steam flowrates optimized

Multiple pinch points

Combined heat and power

Minimum fuel consumption

A Combustion (fossil/biomass)
B Combustion gases recovery
C Water preheating
D HP steam production
E HP steam superheating
F Steam utilisation in process
G Process GCC
H Expansion turbines

Proposed modifications

- Recuperation of heat from secondary refiner exhaust steam (21% reduction of utility steam)
- Heat exchangers for whitewater and wood chip heating & use of a condensing extraction turbine, recycle condensate to boilers (10 % reduction of utility steam)
- Higher outlet pressure of boilers to improve cogeneration of electricity

An overview of process energy enhancement