
Process integration

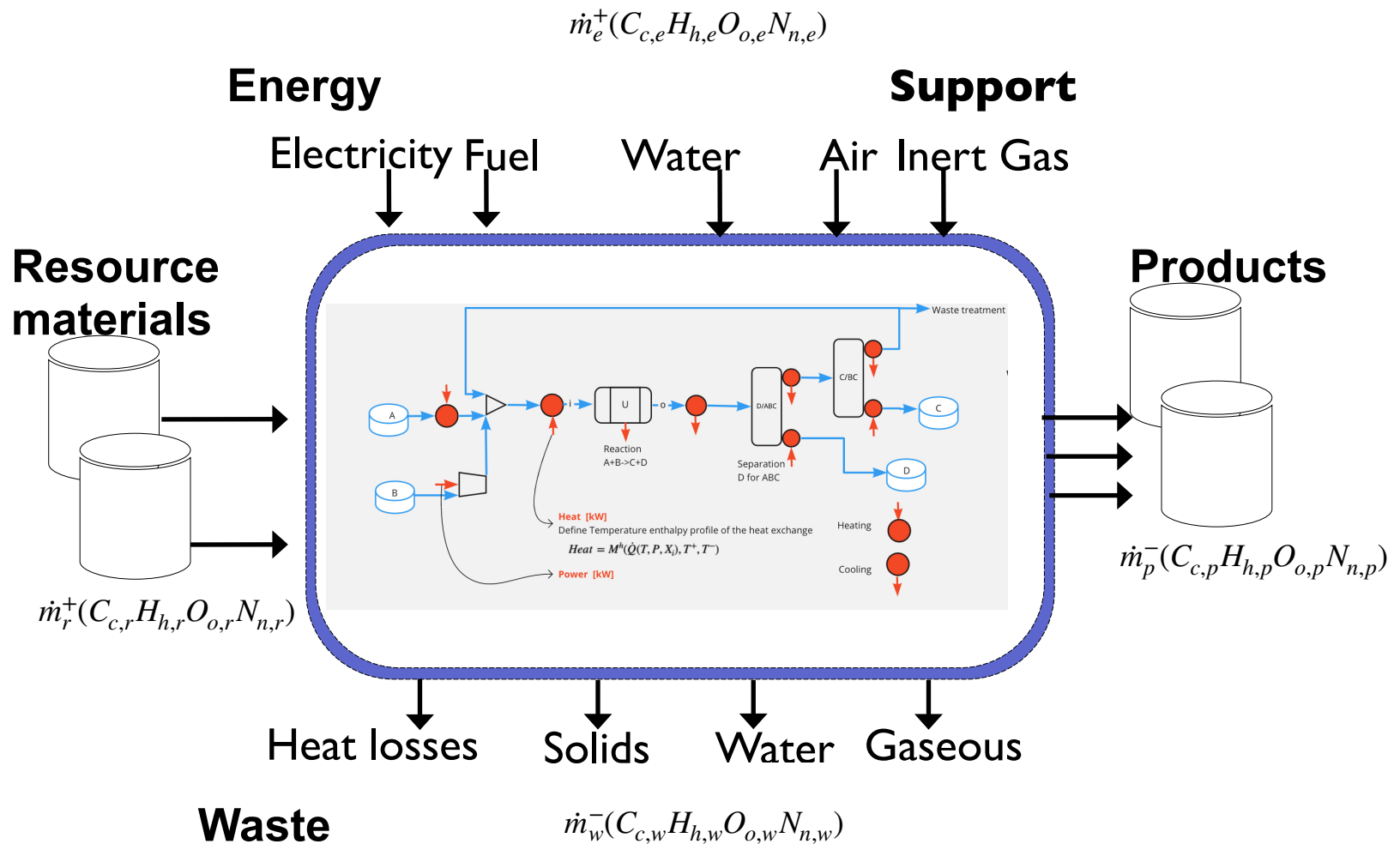
Defining the heat exchange requirements

Prof François Maréchal

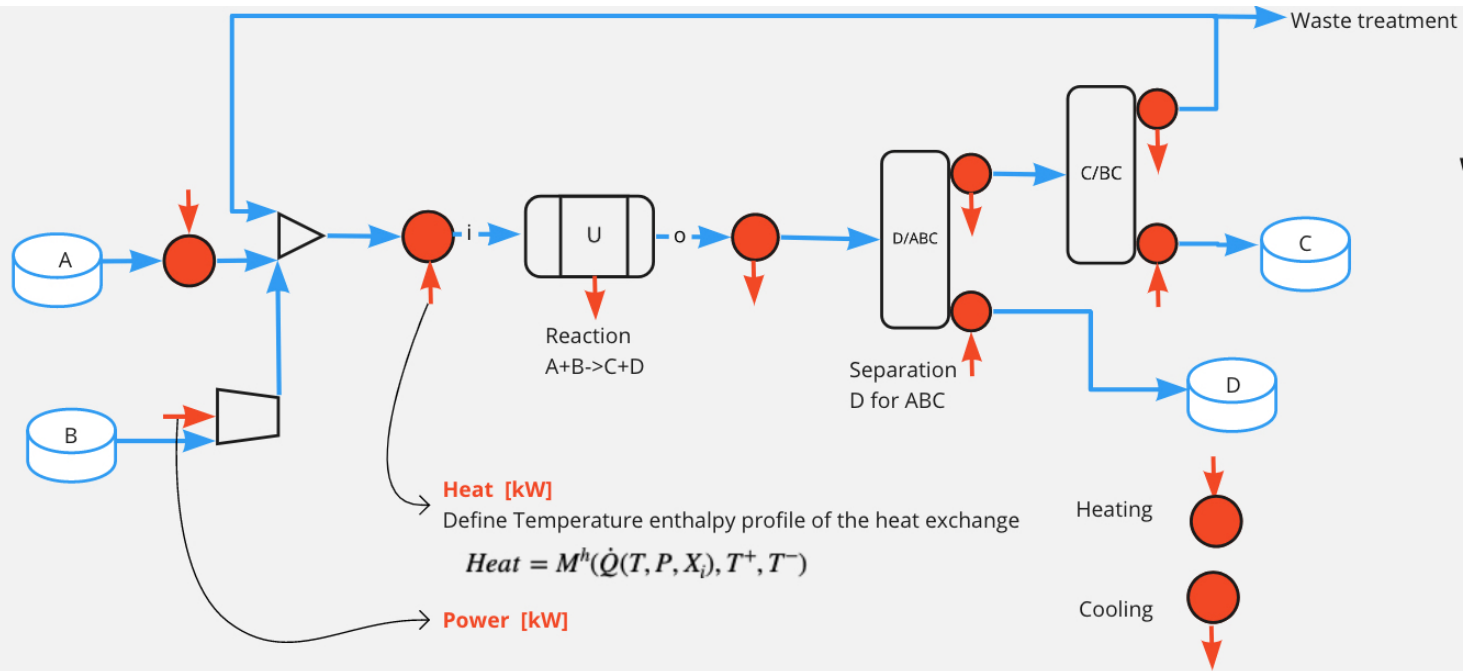
IPESE-IGM-EPFL

Industrial Process and Energy Systems Engineering

Process performance evaluation



Process simulation :



OPEX : operating expenditure

$$OPEX[CHF/year] = \int_{t_0}^{t_f} \left(\sum_{F=1}^{n_F} \dot{M}_F^+(t) c_F^+(t) + E^+(t) c_e^+ - E^-(t) c_e^- + \sum_{W=1}^{N_W} \dot{M}_W^-(t) c_W^-(t) \right) - \sum_{BP=1}^{N_{BP}} \dot{M}_{BP}^-(t) c_{BP}^-(t) - \dot{M}_p^-(t) c_p^-(t) dt$$

cost of raw materials

cost of energy supply

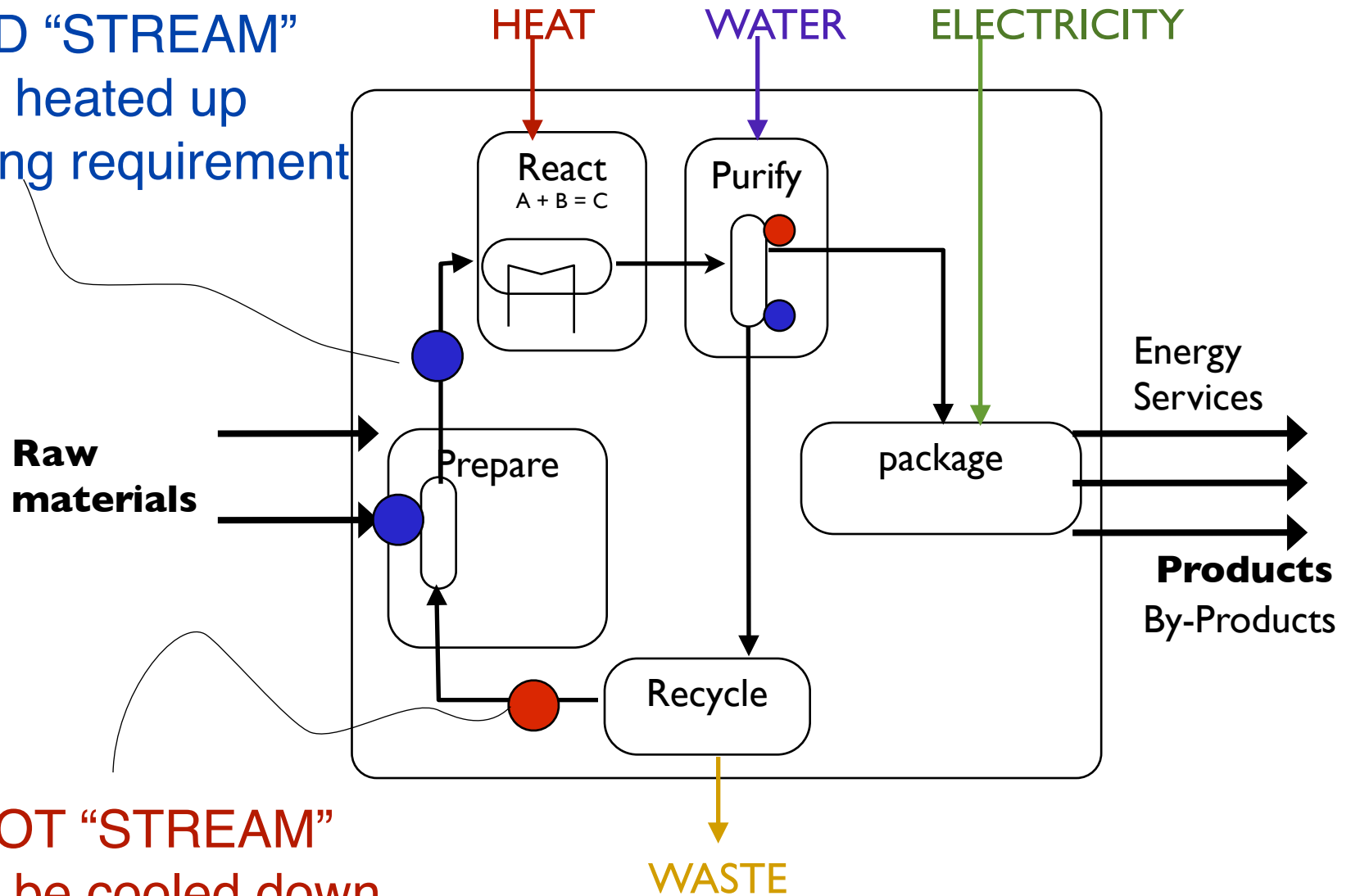
cost of waste produced

profit of by-products

profit of main-products

Process analysis : process units

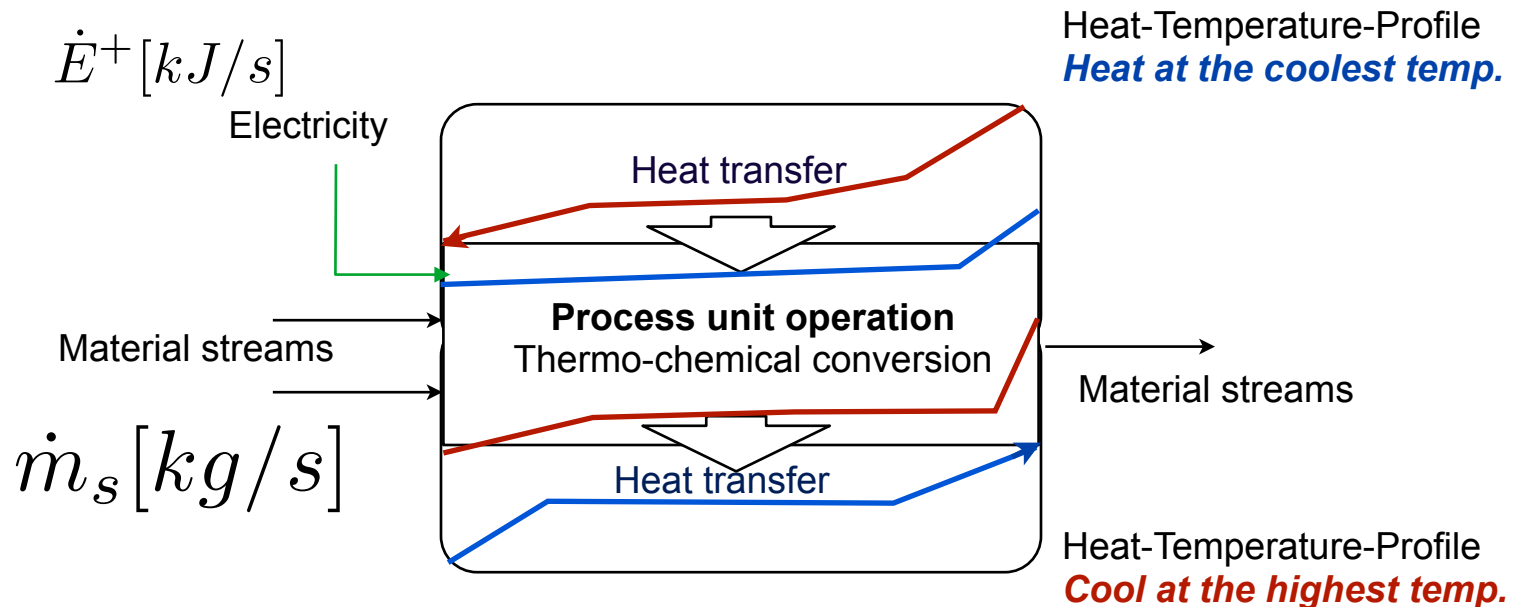
COLD “STREAM”
to be heated up
heating requirement



HOT “STREAM”
to be cooled down
cooling requirement

Heat transfer requirement interface

Process unit operation



$$\dot{m}_s [kg/s] = m_s [kg/kgproduct] \cdot \dot{M}_p [kgproduct/s]$$

*What are the streams that do require heat transfer ?
Characterise them with Heat-Temperature profiles*

Identify the heat transfer requirements

Heat load $\dot{Q} = -\dot{m}_c \int_{T_{in,c}}^{T_{out,c}} cp_c dT \simeq \dot{m}_c cp_c (T_{in,c} - T_{out,c})$

Target State

- Environment
- to process unit operation

Inlet State

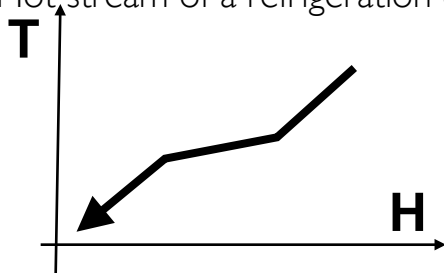
- Environment
- from process unit operation

Hot Streams

---> To be cooled down

Examples

- Distillation condenser
- Exothermic reactor
- Fumes
- Steam condenser
- Hot stream of a refrigeration cycle



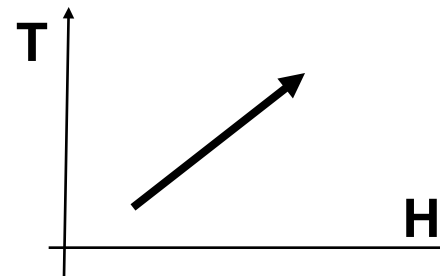
Heat/temperature profile

Cold Streams

---> To be heated up

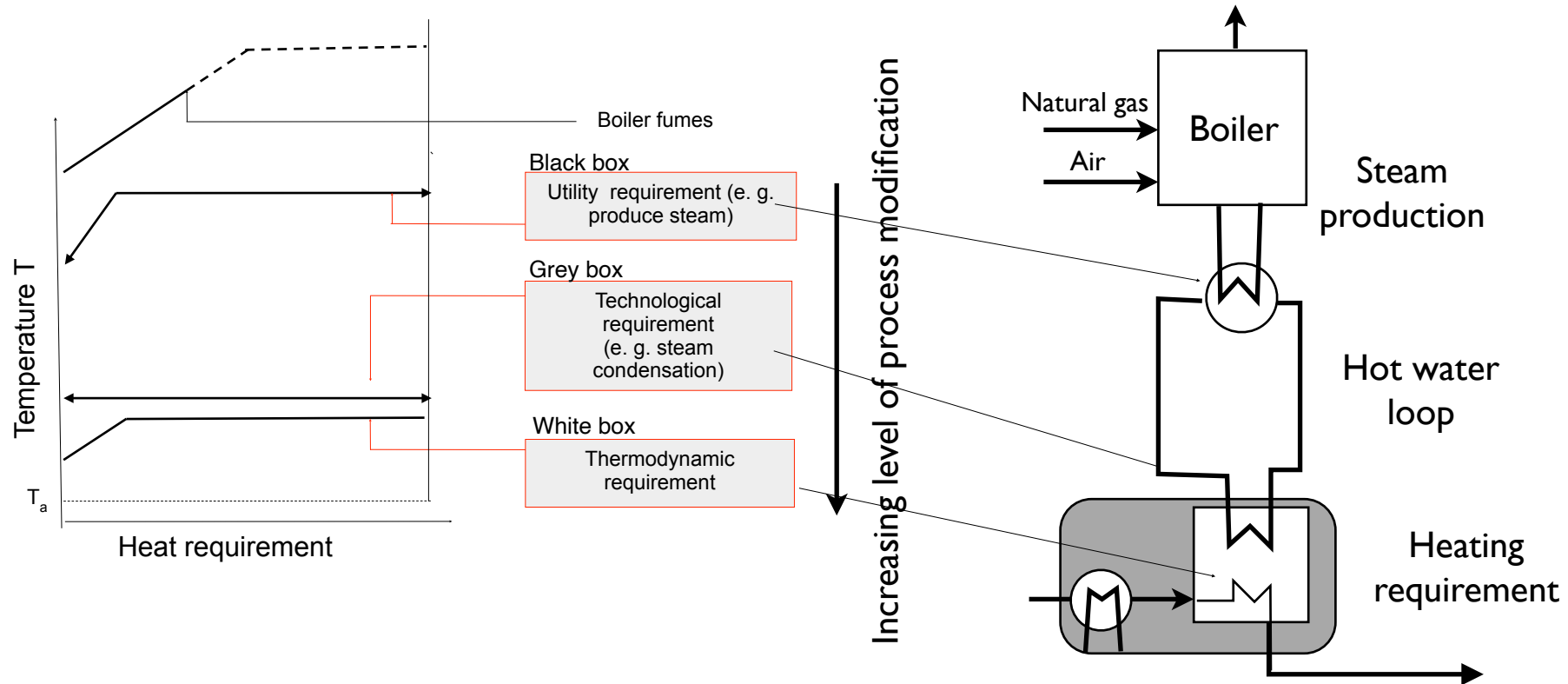
Examples

- Distillation boilers
- Reactants Preheating
- Cooling water
- Steam production
- Cold stream of a refrigeration cycle

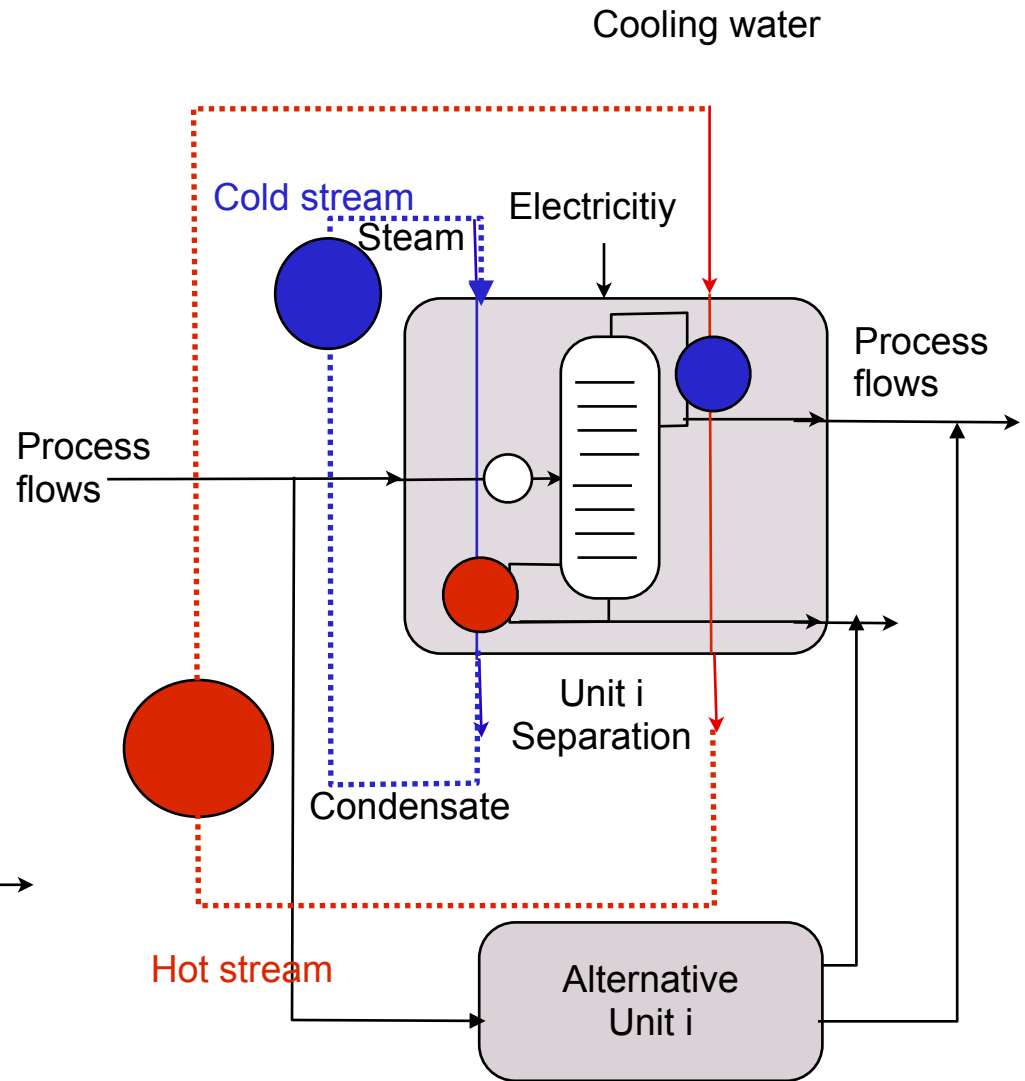
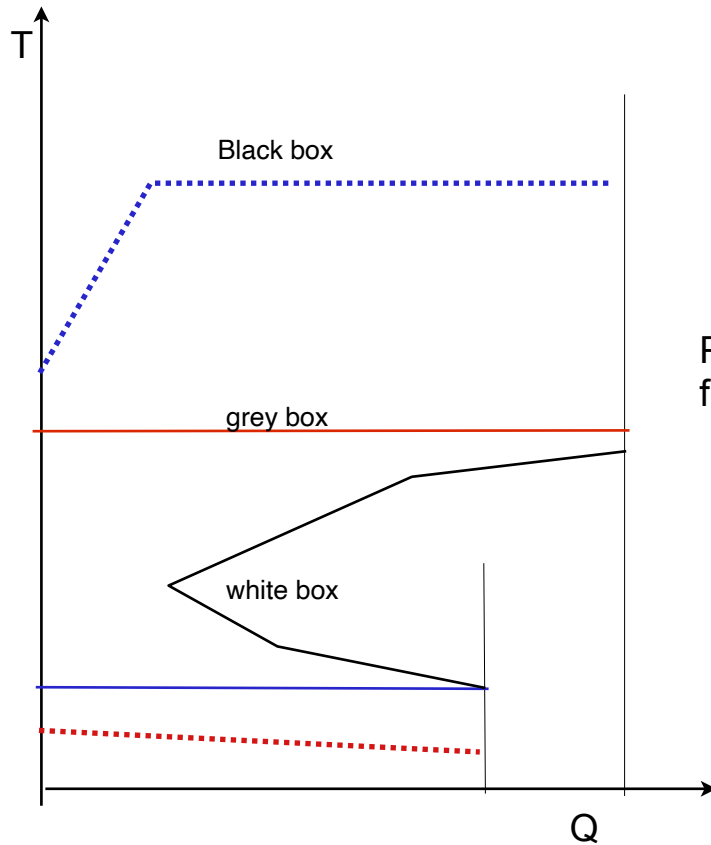


Heat/temperature profile

Different process heat transfer interfaces

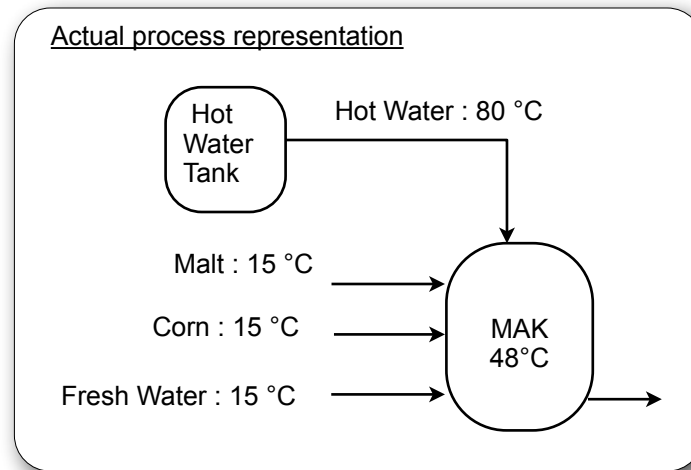


Defining Unit Operation Interfaces



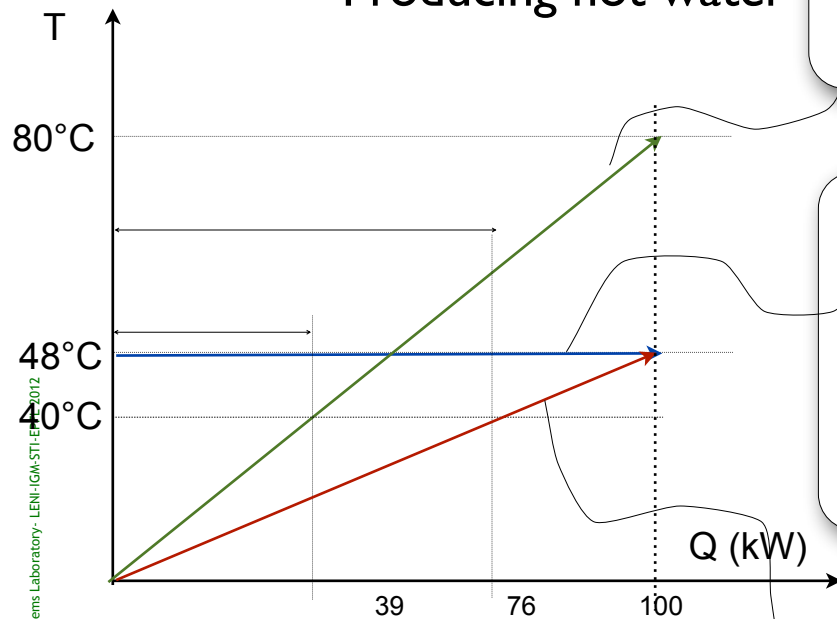
Unit operation MAK

Actual process representation

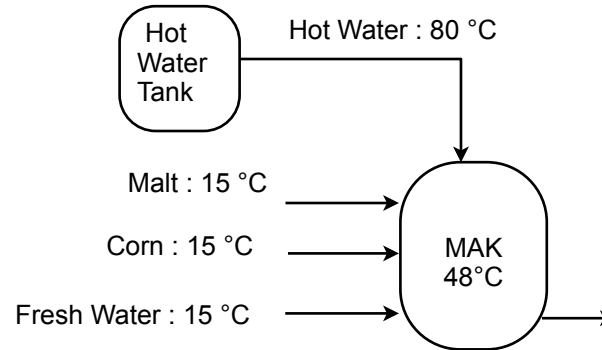


Unit operation

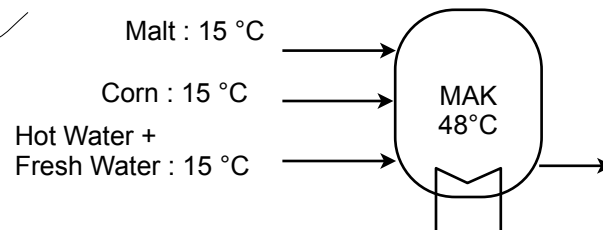
Producing hot water



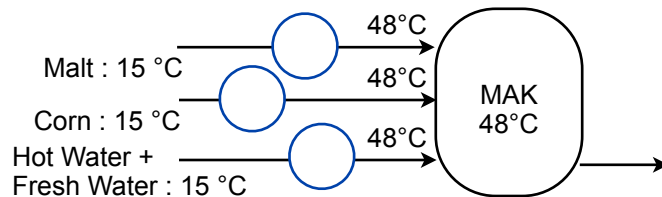
Actual process representation



Vessel heating

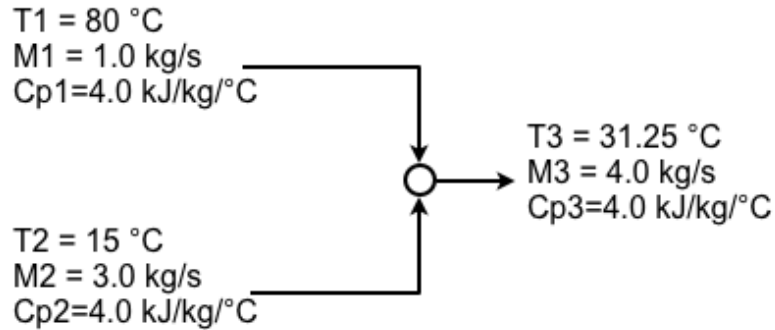


Heat transfer requirement

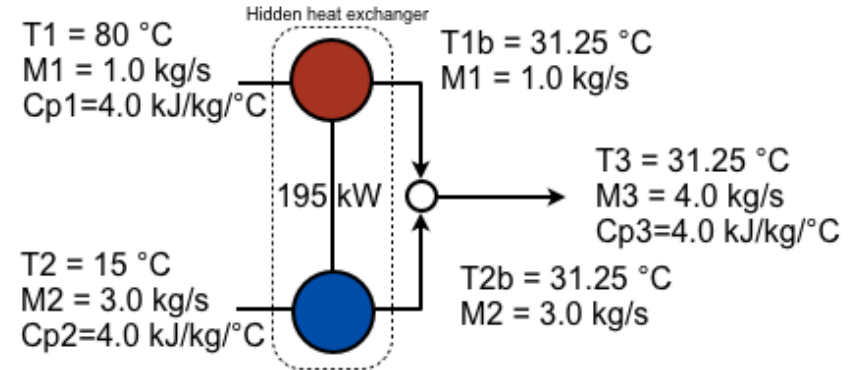


Mixer representation

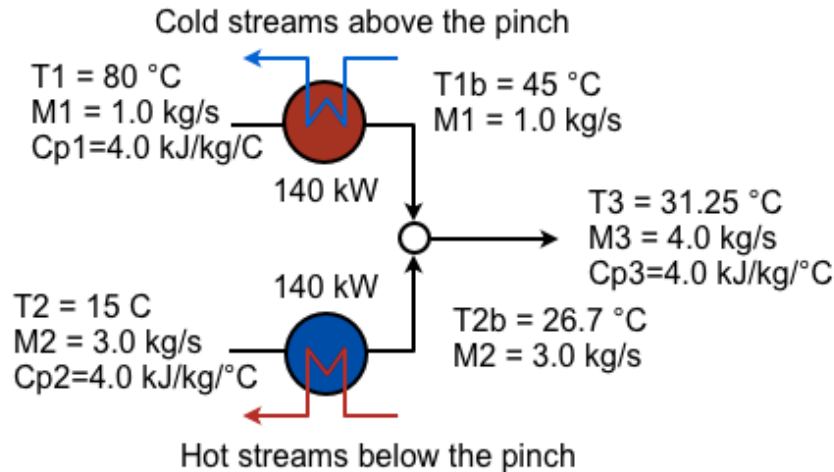
Flowsheet representation



Heat transfer requirement



Heat exchange after pinch identification



Hot and cold streams of the mixer

