Solar thermal Integration into industrial Processes

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Energy Audit Methodology

PRE – AUDIT
(steps 1 - 4)

↓

AUDIT
(steps 5 - 6)

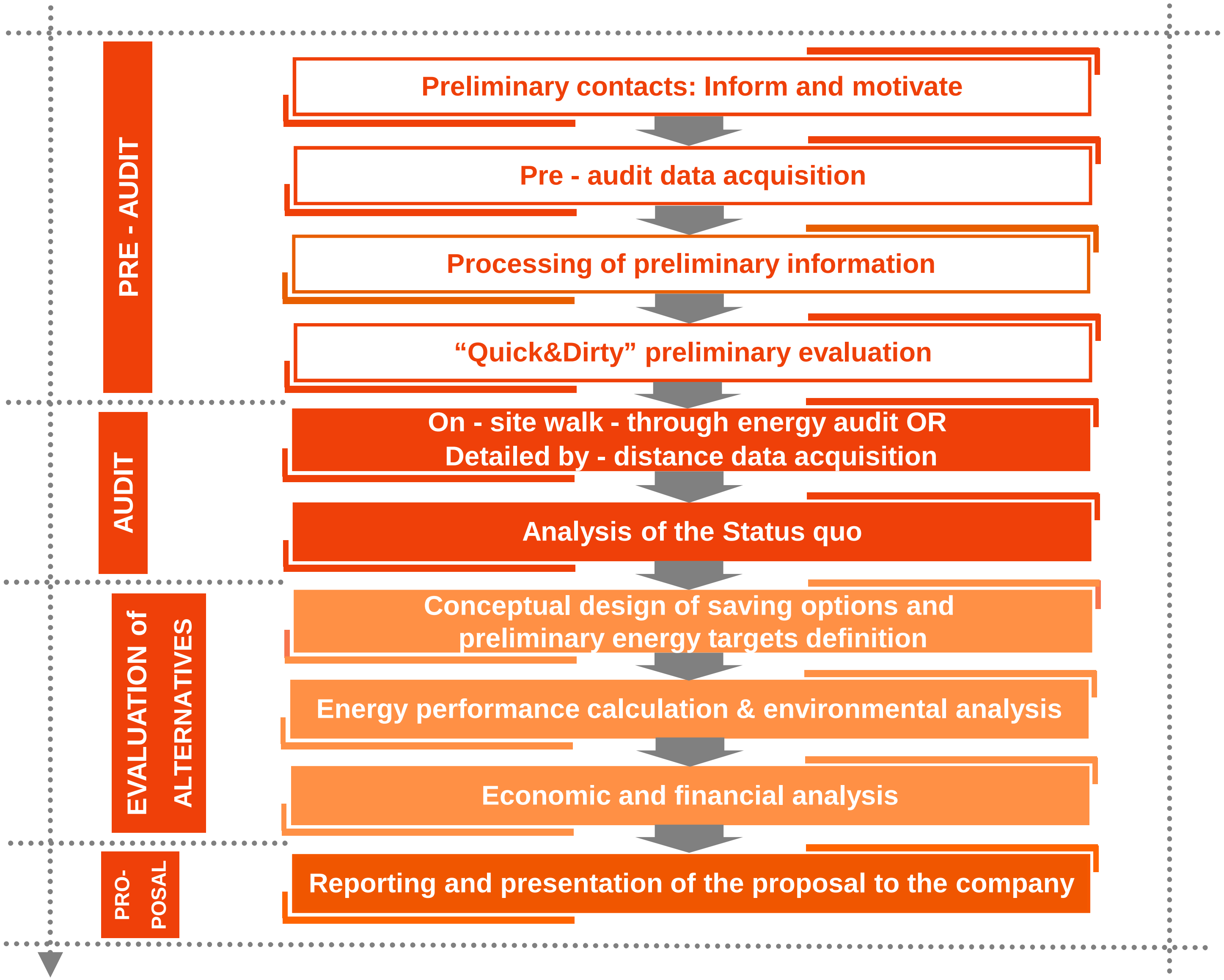
↓

EVALUATION OF ALTERNATIVES
(steps 7 - 9)

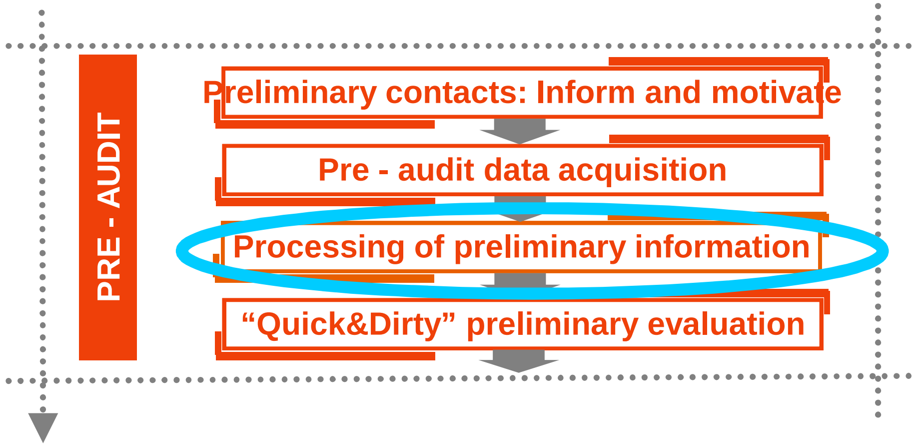
↓

PROPOSAL
(step 10)

10 Audit steps



PRE – AUDIT: STEP 3



EINSTEIN Step 3: Ppreparation of audit. Processing of preliminary information

> process pre-audit data

> call the company to check data

> compare with benchmark data

> learn about specific processes/companies

> identify possible measures

> fix priorities for audit

STEP 2.1: Pre-audit data acquisition

- **Preparation of the company**
  - They should collect:
    - **General situation of the company**
    - **Fuel and electricity bills**
    - **Description of the production process (flowchart with temperatures and mass flows)**
    - **Description of the different processes**
    - **Description of the heat and cold supply system**
    - **Description of the buildings, production halls and stores**

Data should be sent to the auditor in advance

STEP 2.2: Pre-audit data acquisition

- **Preparation of the auditor:**
- **Most relevant processes in the sector?**
  - ⇨ Which processes consume most energy?
- **Existing options for process technologies?**
  - ⇨ What are their advantages and disadvantages?
- **For non-industrial sectors**
  - ⇨ Which aspects consume most energy

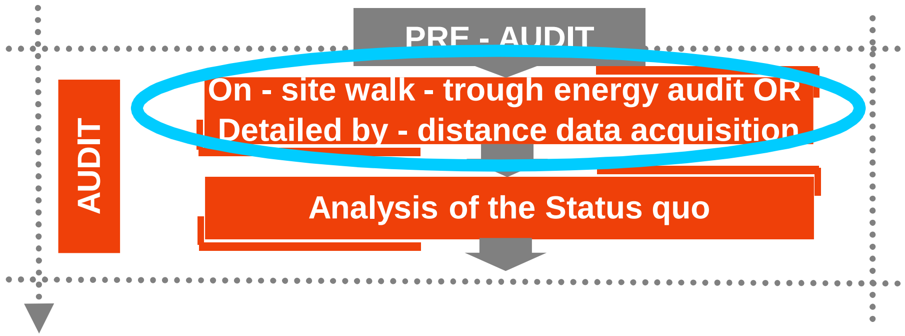
See EINSTEIN tool-kit for sources of information

Study the flow sheet sent by the company

STEP 2.2: Pre-audit data acquisition

- General data
- Energy consumption
- Heat supply equipments
- Machine house
- Process description
- Heat storages
- Heat exchangers
- Building

ENERGY AUDIT: STEP 5



EINSTEIN Step 5: on - site walk - through audit

> present to company quick-and-dirty study

> make interviews and visit the site

> fast check of new data

> take measurements

> define measurement program

> discuss new understanding

Quick temperature measurements with IR equipment

Ensure technical staff present

Use EINSTEIN questionnaire as a guide

STEP 5.2: Types of data

- **General information:**
  - ⇨ Annual production
  - ⇨ What processes? How do they run?
  - ⇨ Activity figures (turnover, number of workers,…)
  - ⇨ Shifts, holiday periods, production schedules…
  - ⇨ Plans for the future?
- **Fuel and electricity bills and energy tariffs:**
  - ⇨ Try to get information for several years !!!
  - ⇨ Breakdown of consumption by
    - **Processes**
    - **Equipment**
    - **Production lines**

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STEP 5.2: Types of data

- **Data on processes:**
- **Often overall energy consumption is available, but not the breakdown by process - additional data is necessary**
  - ⇨ Fluid/energy inflow and outflow
    - **Volume or mass flowrate and temperatures**
  - ⇨ Mass or volume to be heated at start-up
    - **Number of batches or breaks, initial temperature from which equipment has to be heated**
  - ⇨ Thermal losses of process equipment in operation
    - **Power requirement of process to maintain given temperature may be composed of thermal losses, phase-change of working fluids, chemical reactions**

STEP 5.2: Types of data

- **Data on heat and cold supply equipment**
  - ⇨ Get not only nominal power, but also operating hours, load factor, losses
  - ⇨ Make a block diagram: which equipment supplies which process
- **Data on heat and cold distribution and storage**
  - ⇨ Get data on length, diameter, insulation of pipes, temperatures, pressure levels, flow rates
    - **This helps to calculate the energy consumption**
  - ⇨ Identify heat storage: volume, temperature level, pressure, insulation, inlet and outlet flow rates
- **Existing heat recovery systems**
  - ⇨ Identify existing heat exchangers for heat recovery (technical data, type e.g. plate HEX)
  - ⇨ Estimate (typical) real operating conditions (flow rates, temperatures)

STEP 5.2: Types of data

- **There is no time to measure all data!!!**
- **Some hints for indirect calculations**
  - ⇨ Calculation of thermal losses:
    - **From cool-down temperature and time**
    - **From approximate size and insulation thickness**
  - ⇨ E.g. in drying process calculate the heat for evaporation
    - **From the difference of humidity in wet and dry product**

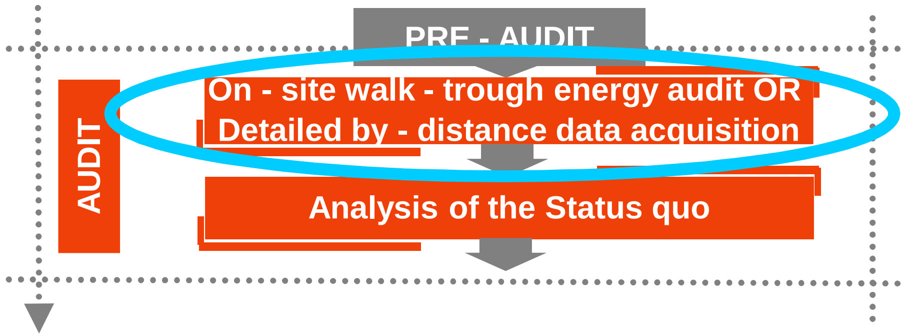
STEP 5.2: Types of data

- **Renewable energies**
  - ⇨ Identify available area (roof and ground), distances and orientation
  - ⇨ Assess availability of biomass or biogas (from processes or vicinity)
  - ⇨ Is there any motivation for renewables besides economics?
- **Building heat & cold demand**
  - ⇨ Make an inventory of existing buildings (offices, storage halls and production halls): heating systems and air-conditioning
  - ⇨ Temperature levels and schedules of use
  - ⇨ Sketches of buildings

STEP 5.2: Types of data

- **Economic and financial parameters**
  - ⇨ Identify O&M costs
  - ⇨ How are investments in energy supply financed (externally, internally, contracting)?
  - ⇨ What are the requirements about pay-back or return rates?

ENERGY AUDIT: STEP 5



EINSTEIN Step 5: on - site walk - through audit

> present to company quick-and-dirty study

> make interviews and visit the site

First impressions: possible measures & unsuitable measures

Timeframe for further data & report

> fast check of new data

Data consistent?

Necessary data missing?

Can ask while on-site

> take measurements

e.g. vessel/pipe wall temperature (for operating temperature & losses)

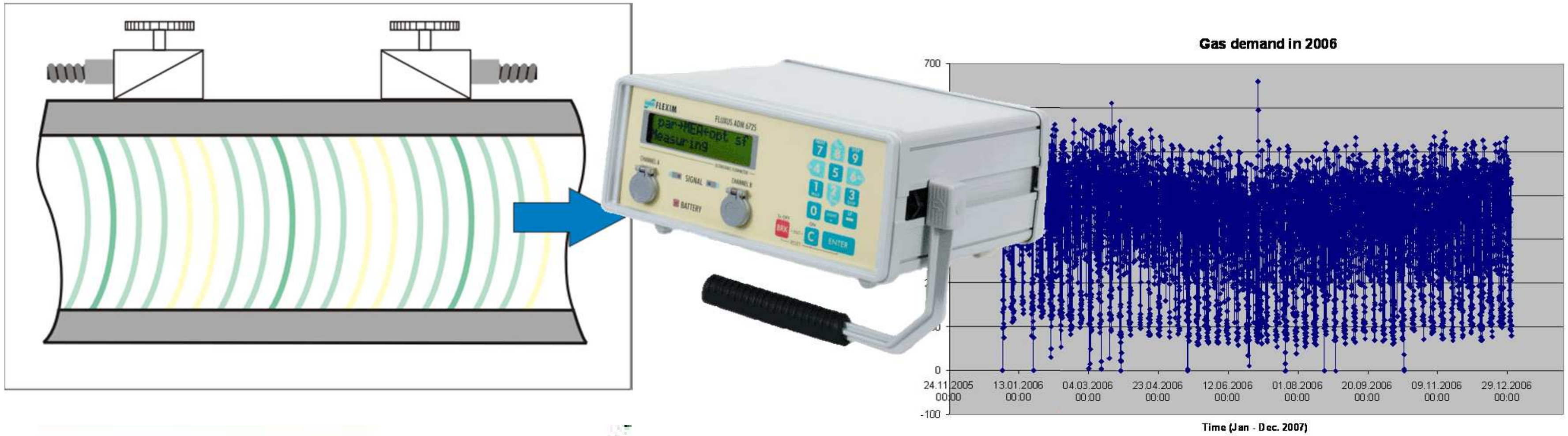
IR temperature measurement

ultrasonic flow meter; bucket & watch

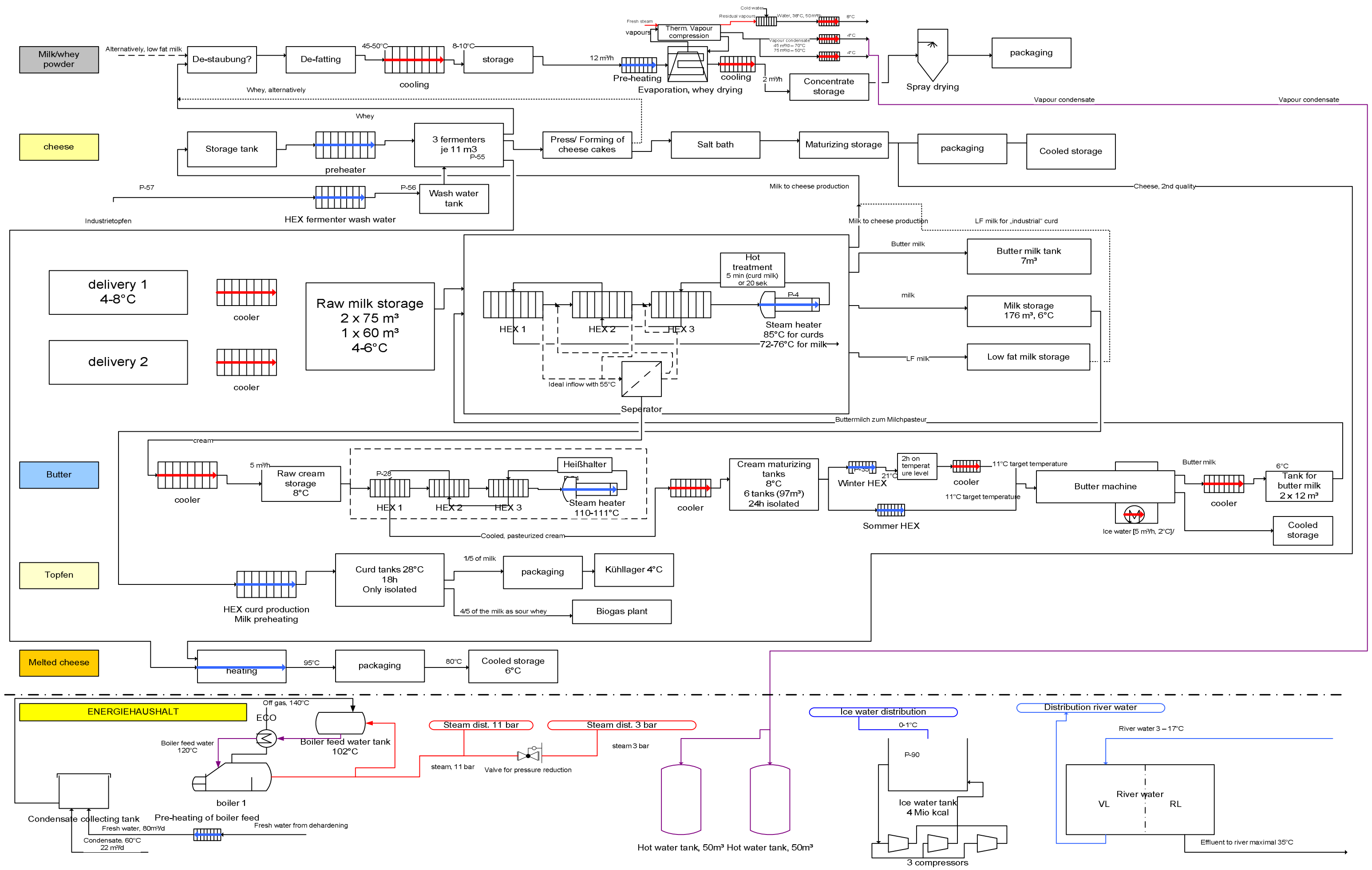
> define measurement program

> discuss new understanding

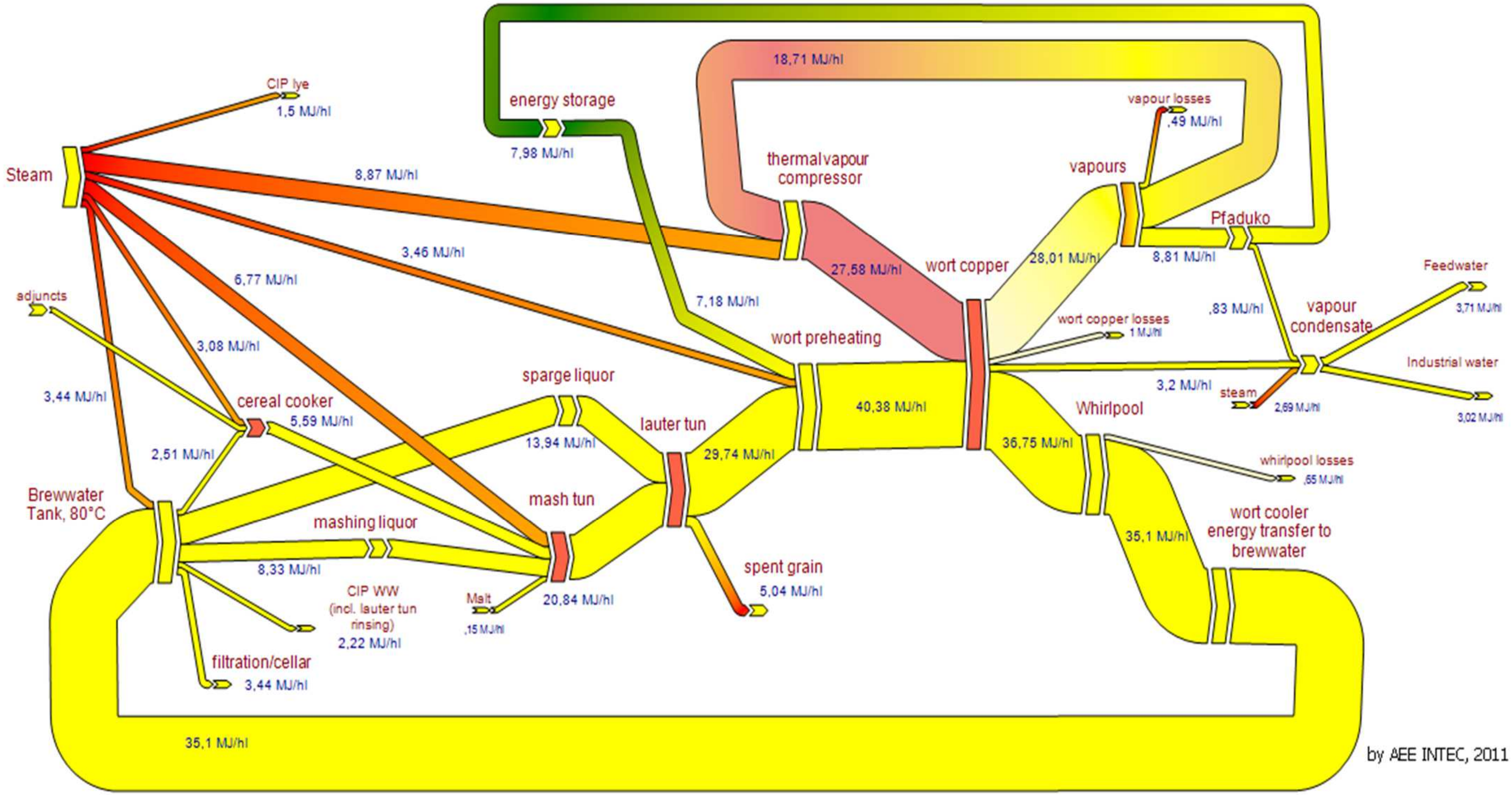
Data acquisition: mass and energy flows



Balancing - Flow sheet

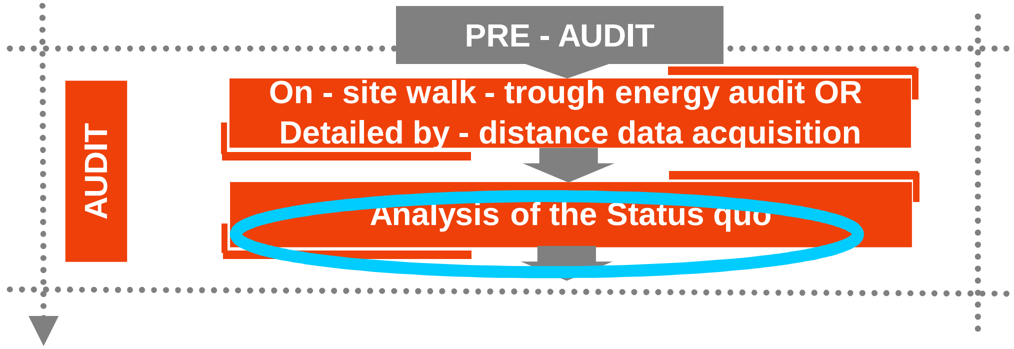


Sankey



Steam
CIP lye
1,5 MJ/hl
energy storage
7,98 MJ/hl
8,87 MJ/hl
18,71 MJ/hl
thermal vapour compressor
vapour losses
,49 MJ/hl
vapours
Pfaduko
8,81 MJ/hl
3,46 MJ/hl
6,77 MJ/hl
27,58 MJ/hl
wort copper
28,01 MJ/hl
7,18 MJ/hl
adjuncts
3,08 MJ/hl
wort preheating
wort copper losses
1 MJ/hl
,83 MJ/hl
vapour condensate
Feedwater
3,71 MJ/hl
Industrial water
3,02 MJ/hl
3,44 MJ/hl
cereal cooker
5,59 MJ/hl
sparge liquor
13,94 MJ/hl
lauter tun
29,74 MJ/hl
40,38 MJ/hl
36,75 MJ/hl
Whirlpool
3,2 MJ/hl
steam
2,69 MJ/hl
whirlpool losses
,65 MJ/hl
2,51 MJ/hl
Brewwater Tank, 80°C
mashing liquor
mash tun
8,33 MJ/hl
CIP WW (incl. lauter tun rinsing)
2,22 MJ/hl
Malt
,15 MJ/hl
20,84 MJ/hl
spent grain
5,04 MJ/hl
35,1 MJ/hl
wort cooler energy transfer to brewwater
filtration/cellar
3,44 MJ/hl
35,1 MJ/hl
by AEE INTEC, 2011

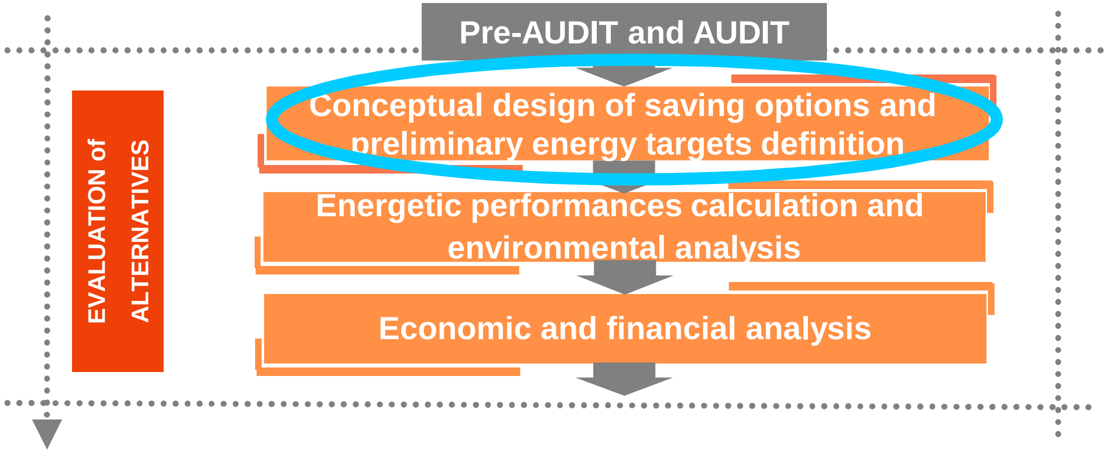
ENERGY AUDIT: STEP 6



EINSTEIN Step 6: analysis of status quo

- > consistency check of data
- > estimate and/or acquire missing information
- > breakdown of consumption
- > real equipment performance
- > comparison with benchmarks

EVALUATION OF ALTERNATIVES: STEP 7



EINSTEIN Step 7: conceptual design of saving options and preliminary energy targets definition

> check list of recommendations for potential energy savings

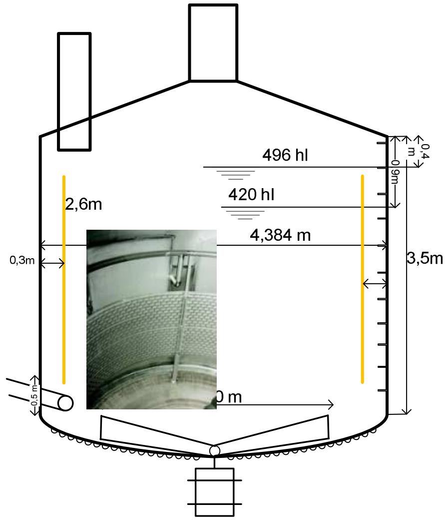
> process optimization and demand side opportunities

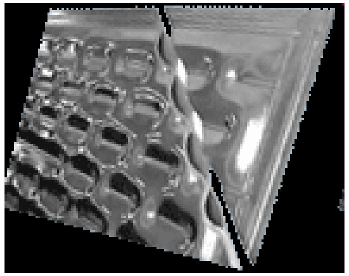
> analyse the theoretical heat recovery potential

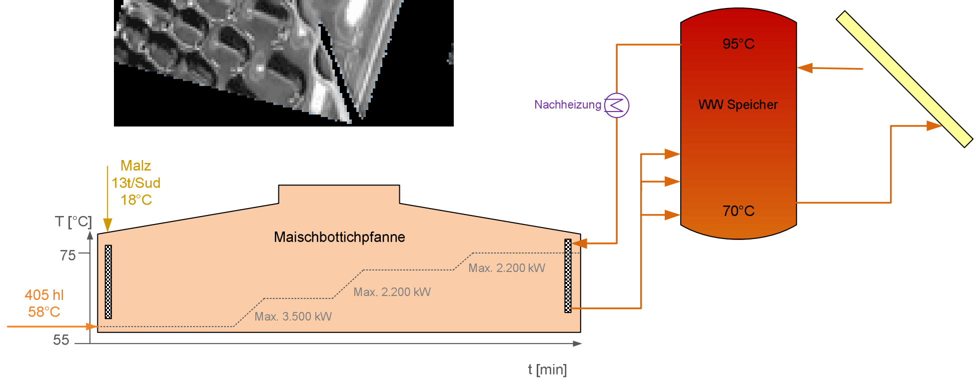
> pre-design heat exchanger and storage network

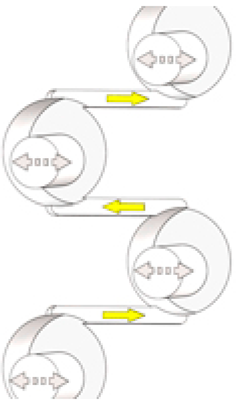
> pre-design of alternative supply systems

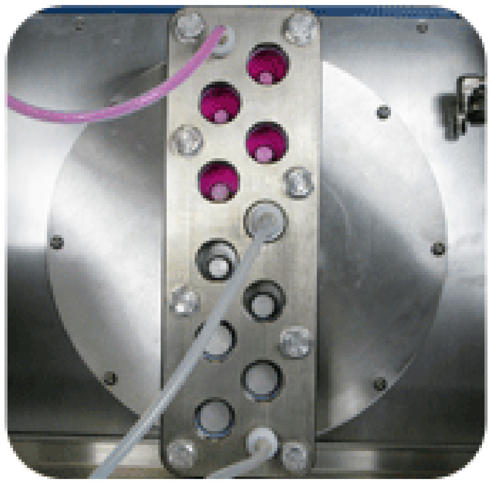
Examples of technology optimization

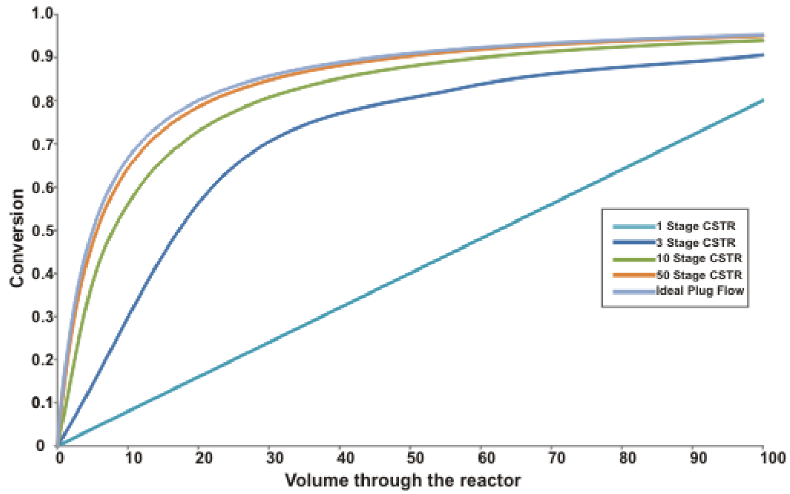












Schritt 3: Matrix of industrial process indicators

Low temperature processes in various industry sectors [edit]

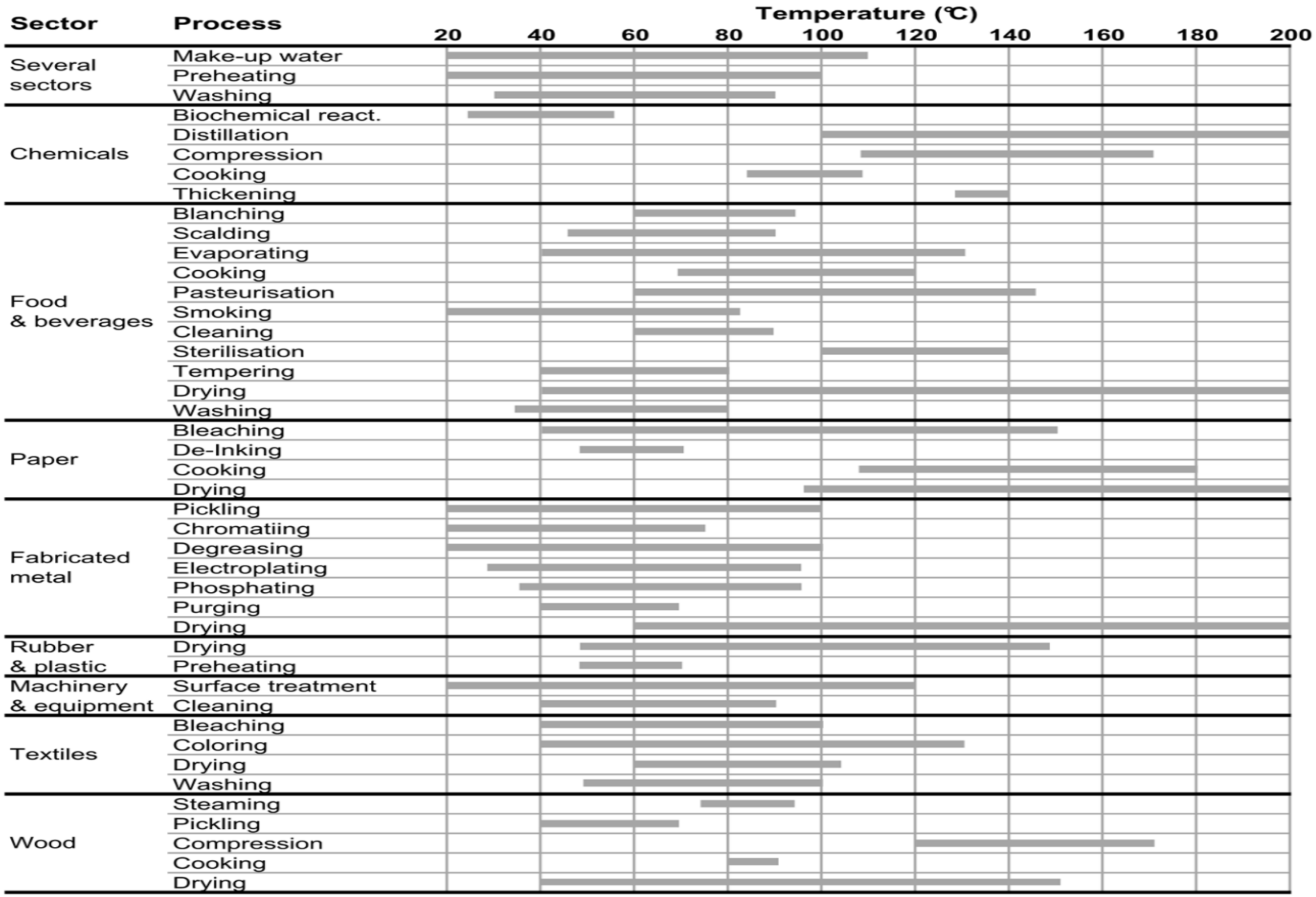
	general description	solar integration schemes	Industry sectors			
UNIT OPERATIONS			Subsection DA food	Subsection DB textiles	Subsection DJ metals	Subsection DG chemicals
		INFO	INFO	INFO	INFO	INFO
CLEANING	info	info	x	x	x	x
DRYING	info	info	x	x	x	x
EVAPORATION & DISTILLATION	info	info	x			x
BLANCHING	info	info	x			
PASTEURIZATION	info	info	x			x
STERILIZATION	info	info	x			x
COOKING	info	info	x	x		
OTHER PROCESS HEATING	info		x	x	x	x
GENERAL PROCESS HEATING	info		x	x	x	x
HEATING OF PRODUCTION HALLS	info	info	x	x	x	x
COOLING OF PRODUCTION HALLS	info		x			x
COOLING PROCESSES	info		x		x	x
MELTING	info	info	x			
EXTRACTION	info		x			
BLEACHING	info		x	x		
PAINTING	info	info		x	x	x
SURFACE TREATMENT	info	info			x	

Schritt 3:Sub Matrix of industrial process indicators

		milk products	fruits/vegetables	sugar	beer	fats/oils	chocolate/cacao/coffee	starch/potatoes/grain mill products	wine/beverages	meat	fish	aroma
UNIT OPERATIONS	Typical processes	info	info	info	info	info	info	info	info	info	info	info
CLEANING	Cleaning of bottles and cases	x	x		x	x			x	x	x	
	Washing products		x	x		x		x	x	x	x	
	Cleaning of production halls and equipment	x	x	x	x	x	x	x	x	x	x	x
DRYING	Drying	x	x	x		x	x	x		x		
EVAPORATION & DISTILLATION	Evaporation	x	x	x		x	x	x	x	x	x	
	Distillation					x		x	x			x
	Deodorization					x	x	x				
BLANCHING	Blanching		x					x				
PASTEURISATION	Pasteurisation	x	x		x			x	x	x	x	
STERILIZATION	Sterilization	x	x					x	x	x	x	
COOKING	Cooking & boiling		x		x		x	x	x	x	x	
OTHER PROCESS HEATING	Pre-heating	x	x		x							
	Soaking		x				x		x			
	Thawing									x	x	
	Peeling		x									
GENERAL PROCESS HEATING	Boiler feed-water preheating	x	x	x	x	x	x	x	x	x	x	x
HEATING OF PRODUCTION HALLS	Heating of production halls			x			x	x	x			x
COOLING OF PRODUCTION HALLS	Cooling of production halls	x	x						x	x	x	
COOLING PROCESSES	Cooling, chilling & cold stabilization	x	x	x	x	x	x	x	x	x	x	
	Ageing	x							x			
MELTING	Melting	x				x	x		x			
EXTRACTION	Extraction		x	x		x	x		x			x
BLEACHING	Bleaching					x						
Temperature level												
20-40 °C		x	x		x		x		x			
40-60 °C		x	x		x		x		x	x		x
60-80 °C		x	x	x	x	x	x	x	x	x		x
>80°C		x	x	x	x	x	x	x	x;			x

Motivation and potentials

Process temperature levels of various industrial processes



Source: IEA SHC Task 49/IV 2013

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Cleaning of bottles an

The basic bottle rinsing process is shown below:

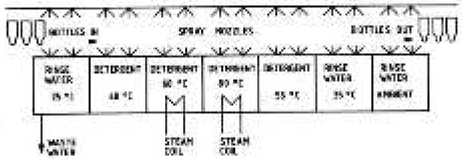


Figure 2: Basic bottle rinsing line

A more detailed description of the bottle cleaning process is shown below:

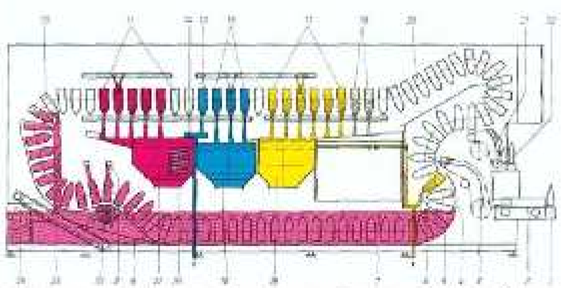
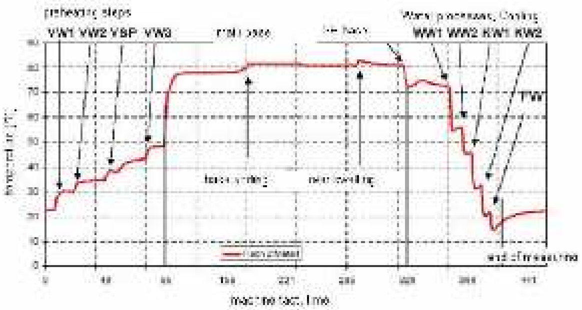


Figure 3: Temperature and pressure parameters in bottle cleaning

- Temperature profile of the cleaning process:

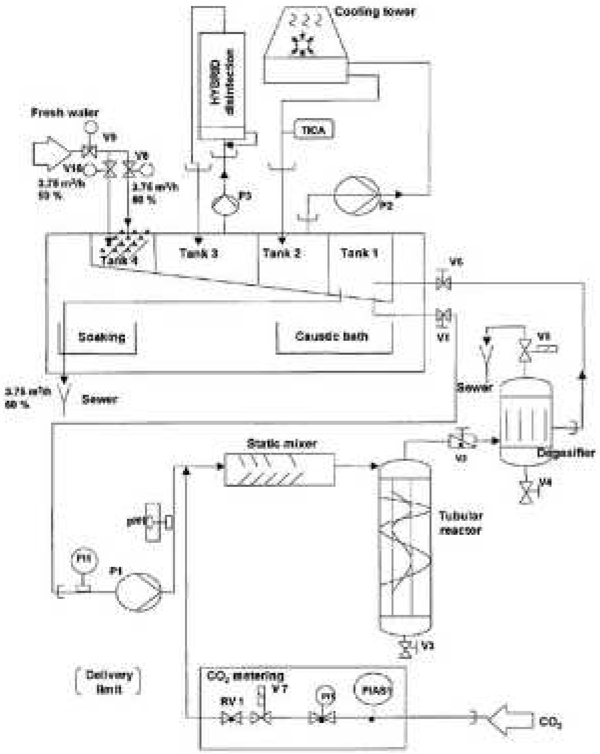


4. COMPETITIVE TECHNOLOGIES AND ENERGY SAVING POTENTIALS

a) Changes in the process:

- Multistage bottle cleaning: (BAT in the Food, Drink and Milk Industries, June 2005)

The multistage bottle cleaning is presented below:

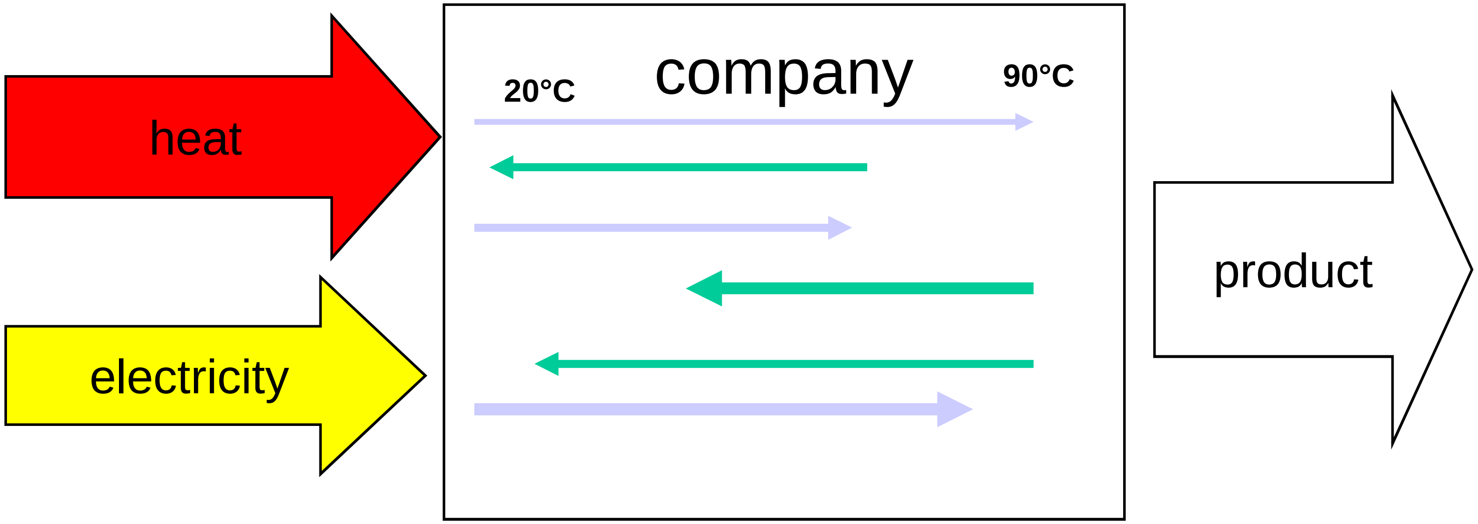


TICA	Temperature instrument control alarm	V	Valves
		PI	Pressure instrument
FI	Flow instrument	P	Pump
RV	Control value	PIAS	Pressure instrument alarm

ıstainable Technologies

Definition of streams

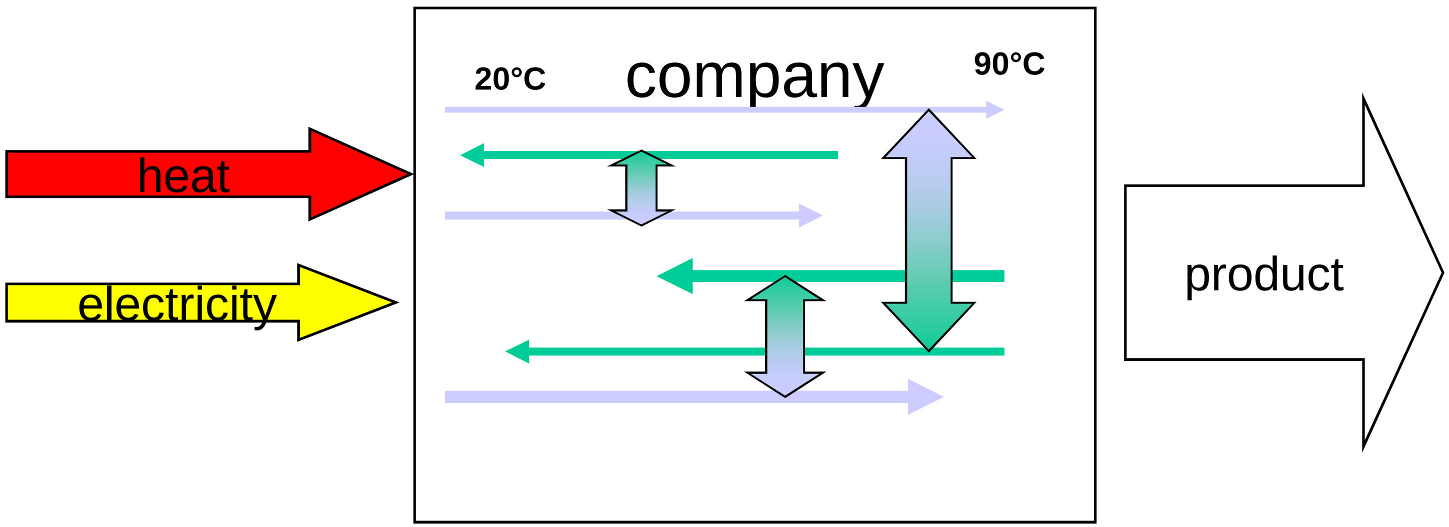
➢ **Heat sources and heat sinks in a company**



Different processes have to heated up or cooled down

Definition of streams

➢ **Reduction of the primary energy demand by heat exchange**



Definition of streams

➢ Enthalpie stream (sensible stream)

$$\dot{Q} = \dot{m} \cdot c_p \cdot \Delta T$$

- ⇨ m mass (kg/s)
- ⇨ cp specific heat capacity (kJ/(kg K))
- ⇨ ΔT temperature difference (K)

➢ Data for calculation

- ⇨ Yearly operating hours for savings
  - **Q [kW] * h [h/a] = E [kWh/a]**
- ⇨ Energy supply €/kWh for economical calculation
- ⇨ Heat transfer coefficient for heat exchange calculation
- ⇨ Material for HX for investment calculation

Stream list

number	Process name	Start Temperature	End Temperature	Heat Capacity Cp	Hot/Cold	relevant to production (p) or waste heat (np)	mass flow m	specific heat capacity cp	specific enthalpy h	Enthalpy H	heat transfer coefficient of fluid α	current energy source / cooling medium
		[°C]	[°C]	[kJ/K.s]			[kg/s]	[kJ/kg.K]	[kW/kg]	[kW]	[W/m².K]	
1	Milchpasteur Erhitzung	65,00	74,00	41,10	Cold	p	10,90	3,77	33,93	369,87	2500,00	fossil gas
2	Milchpasteur Topfen Erhitzung	75,00	85,00	41,75	Cold	p	11,08	3,77	37,70	417,53	2500,00	fossil gas
3	Milchpasteur Kühlung	8,00	6,00	41,17	Hot	p	10,92	3,77	-7,54	-82,34	2500,00	electricity
4	Topfen Erwärmung Topferei	6,00	28,00	15,45	Cold	p	4,10	3,77	82,94	339,87	2500,00	fossil gas
5	Topfen Kühlung im Lager	28,00	4,00	2,29	Hot	p	0,8196	2,80	-67,20	-55,07	2500,00	electricity
6	Rohrahmkühlung	50,00	8,00	4,13	Hot	p	1,4330	2,88	-120,96	-173,34	2500,00	thermal
7	Rahmpasteur Erhitzer	90,00	111,00	3,30	Cold	p	1,147	2,88	60,48	69,35	2500,00	fossil gas
8	Rahmpasteur Kühlung	10,00	8,00	3,30	Hot	p	1,147	2,88	-5,76	-6,60	2500,00	electricity
9	Rahm WinterWT	8,00	21,00	12,66	Cold	p	4,395	2,88	37,44	164,55	2500,00	fossil gas

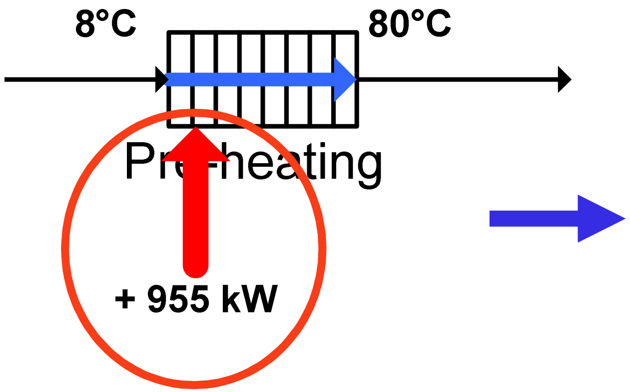
Aims of Pinch Analysis

- **Visualization of the total cold- and heat demand of a system in one diagram**
  - ⇨ energy demand of single processes
  - ⇨ at which temperature level the energy has to be supplied
- **Maximum of heat recovery**
- **Heat exchanger network – combination of the process streams**
- **Be aware of existing piping systems and heat exchangers and the location of the buildings and processes**

Definition

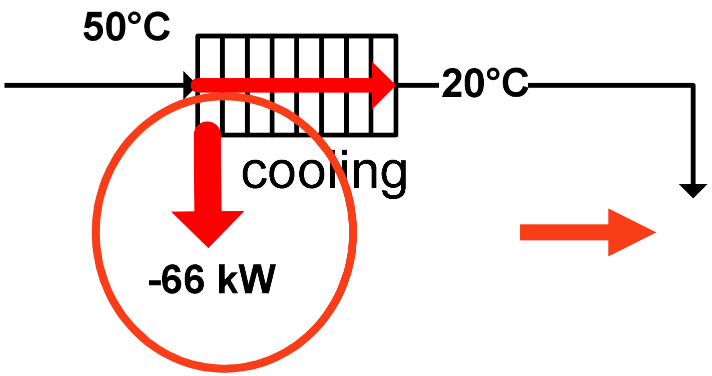
- **energy – anergy – exergy**
- **enthalpy: internal energy and pushing duties**
- **internal Energy depending from T:**
  - ⇨ DH = m×cp ×(T2 -T1)
    - **DH = enthalpy difference [J], [kJ]**
    - **m = mass [kg]**
    - **cp = specific heat capacity with constant pressure [J/(kg_K)]**
    - **T2 = higher absolute temperature [K]**
    - **T1 = lower absolute temperature [K]**
  - ⇨ power $\dot{Q} = \dot{m} \cdot c_p \cdot \Delta T$

Hot and cold streams



„Cold streams“ need to be heated

Any process in which **energy input is needed** for heating the process flow/stream

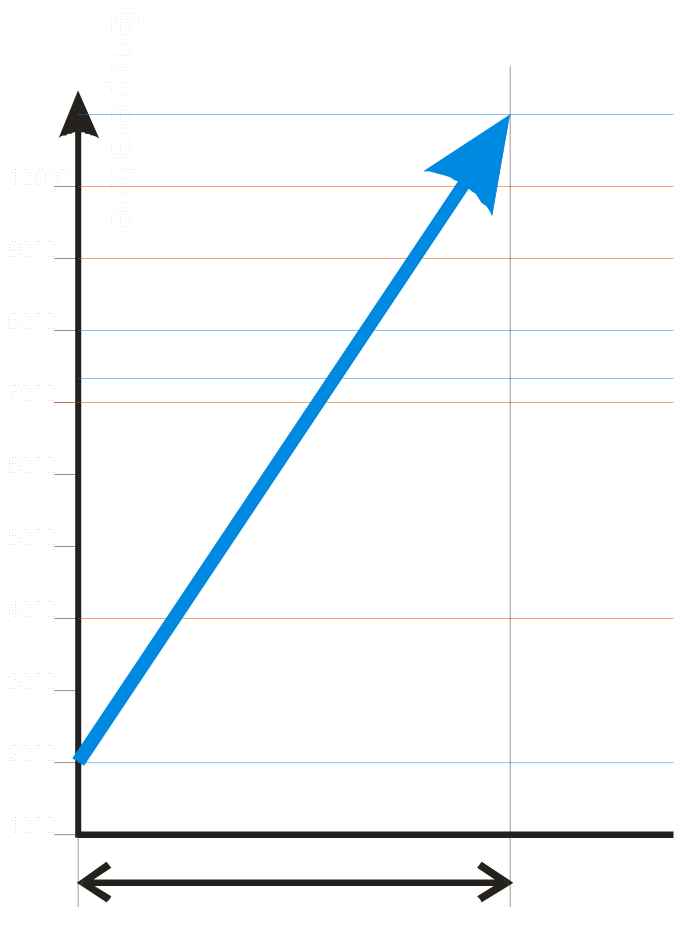


„Hot streams“ need to be cooled

Any process in which **energy input is withdrawn** for cooling the process flow/stream

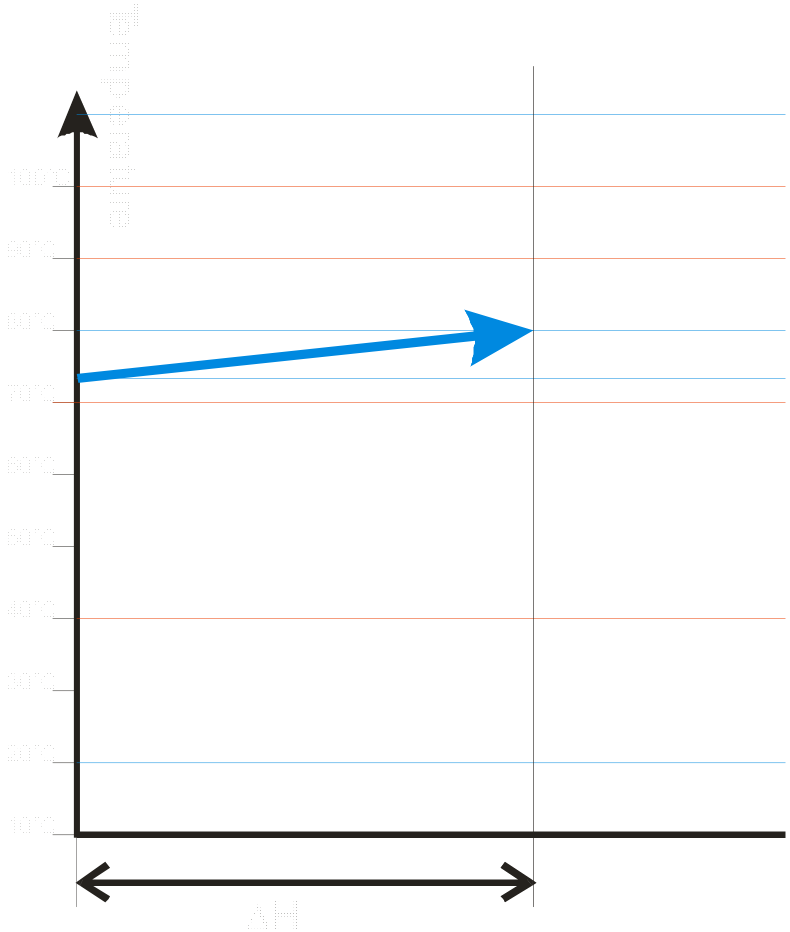
Example 1 - Temperature-enthalpy profile

- **Heat up 47,8 kg/h water from 20 to 110°C**
- **P = ?, dH = ?**

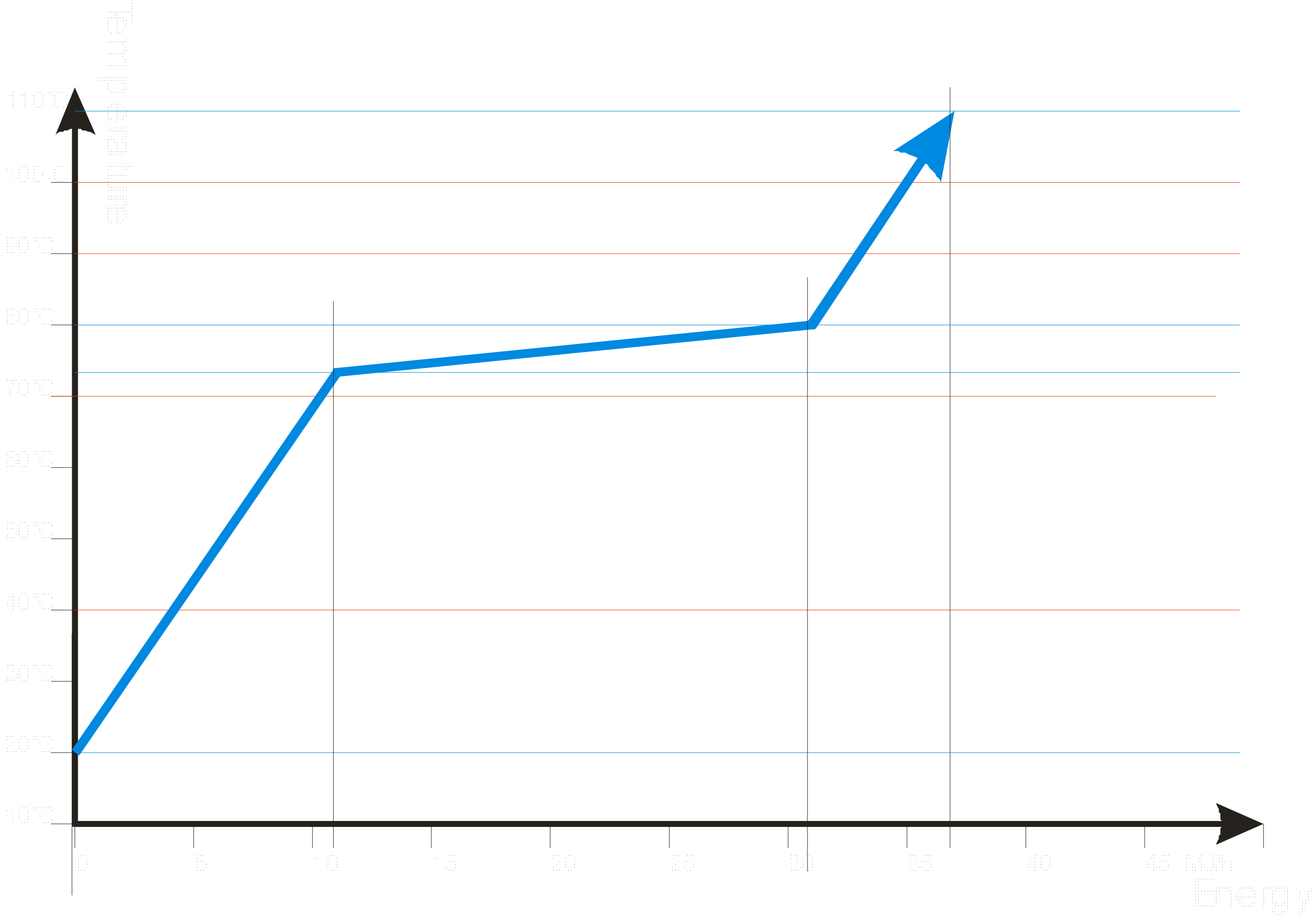


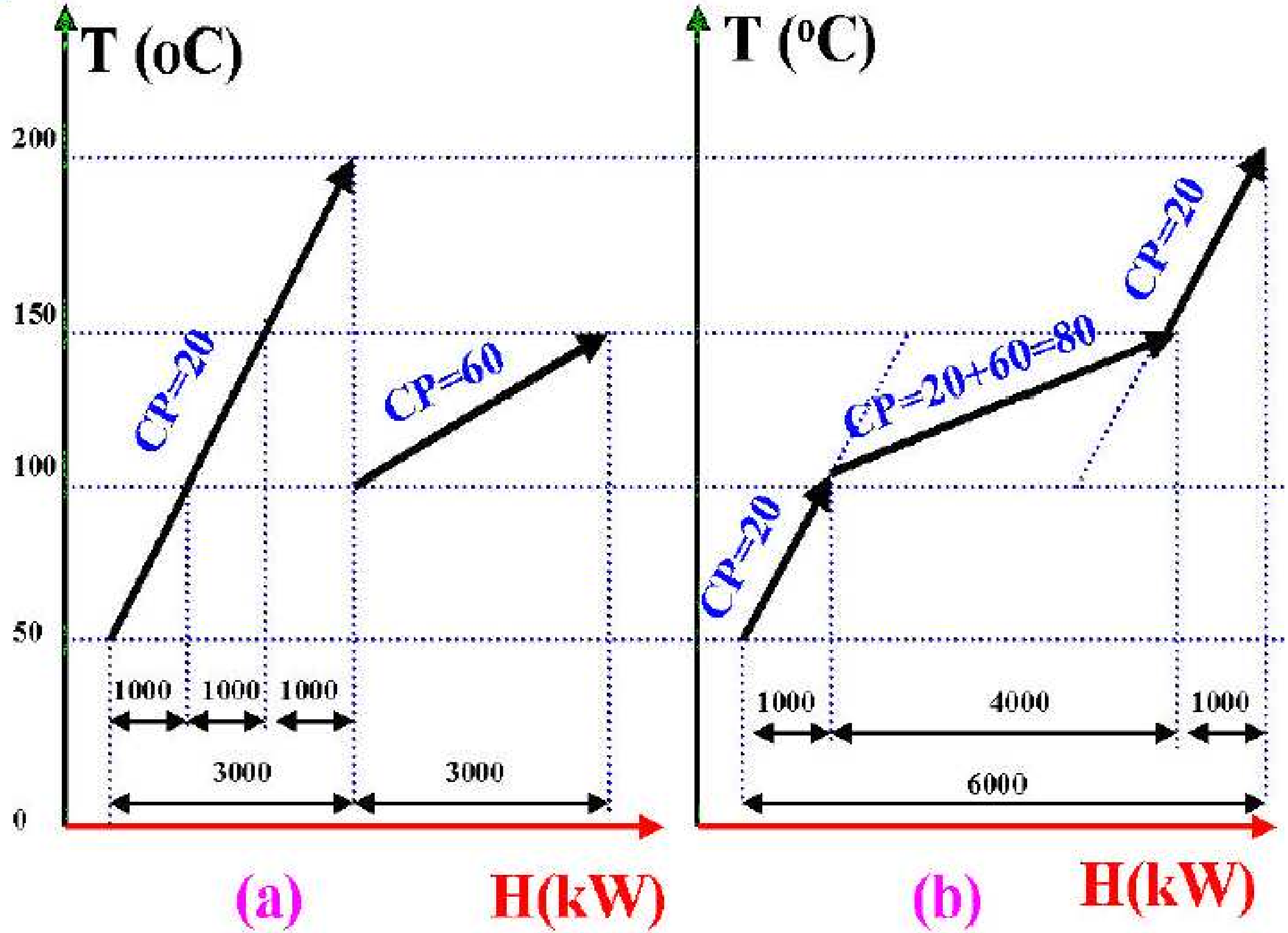
Example 2

- **Heat up 636 kg/h water from 73 to 80°C**
- **P = ?, dH = ?**

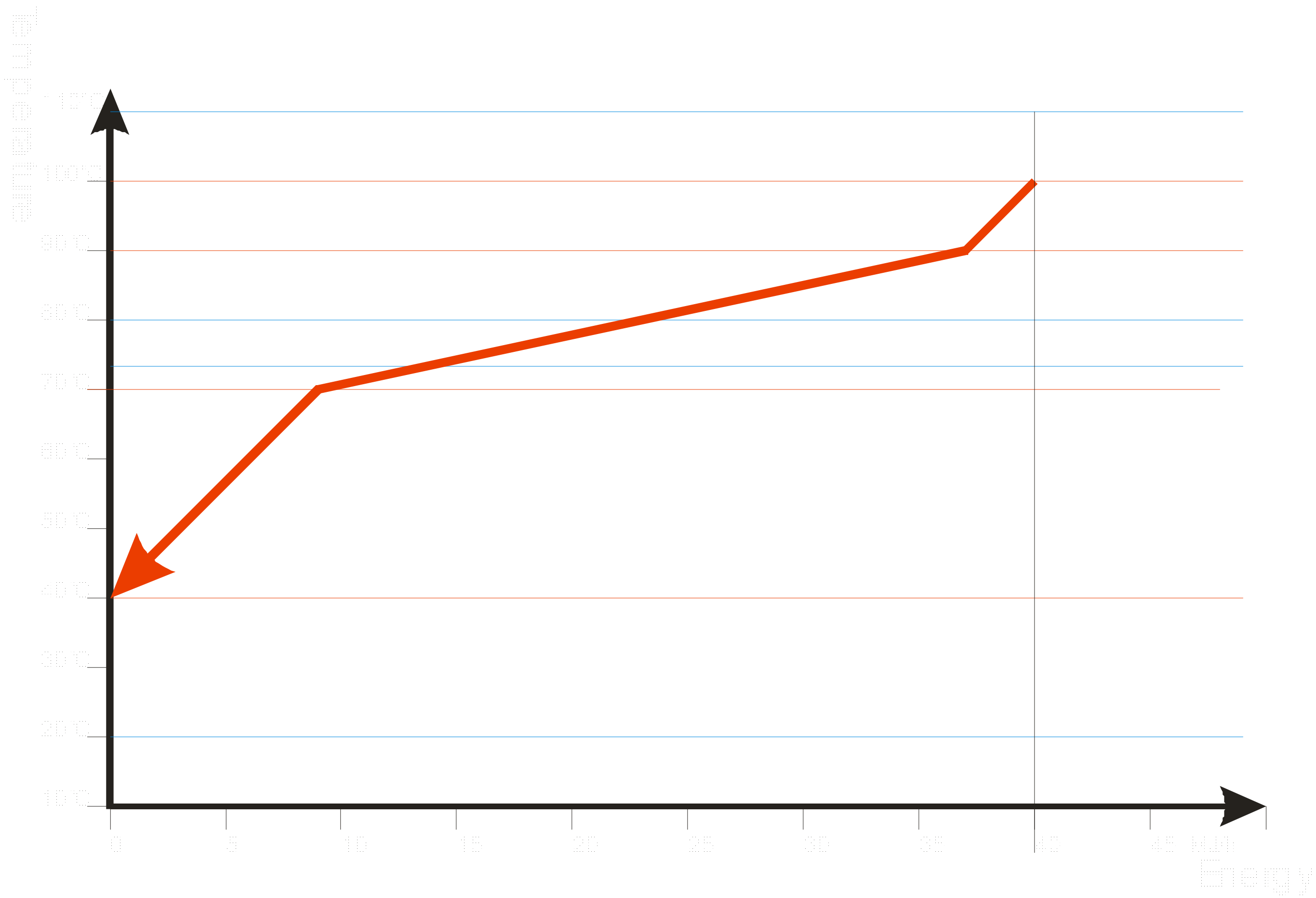


Total heat demand - cold composite curve CCC

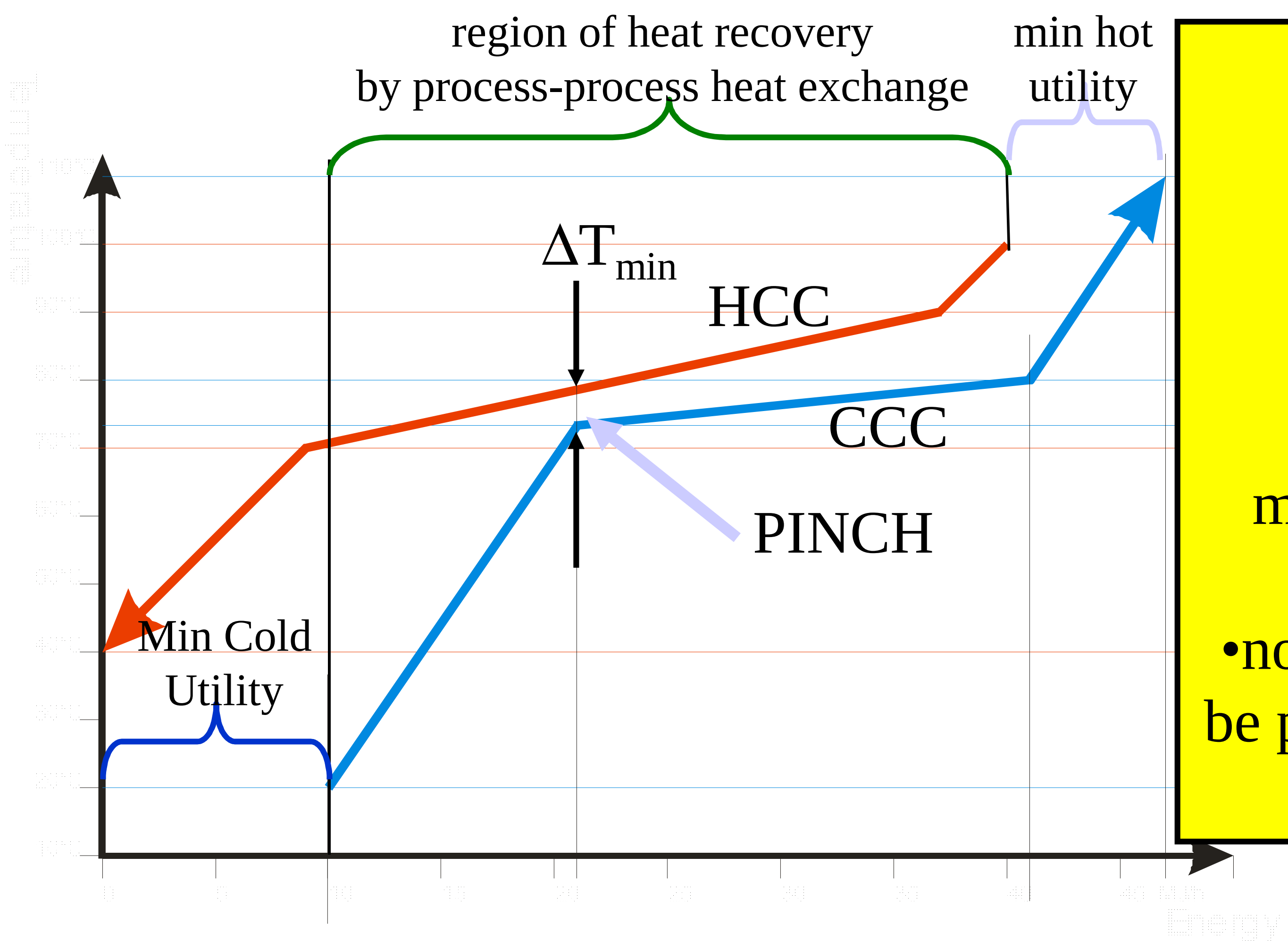



T (oC)
200
150
100
50
0
CP=20
CP=60
1000
1000
1000
3000
3000
(a)
H(kW)
T (°C)
CP=20
CP=20+60=80
CP=20
1000
4000
1000
6000
(b)
H(kW)

Total waste heat for recovery - hot composite curve HCC



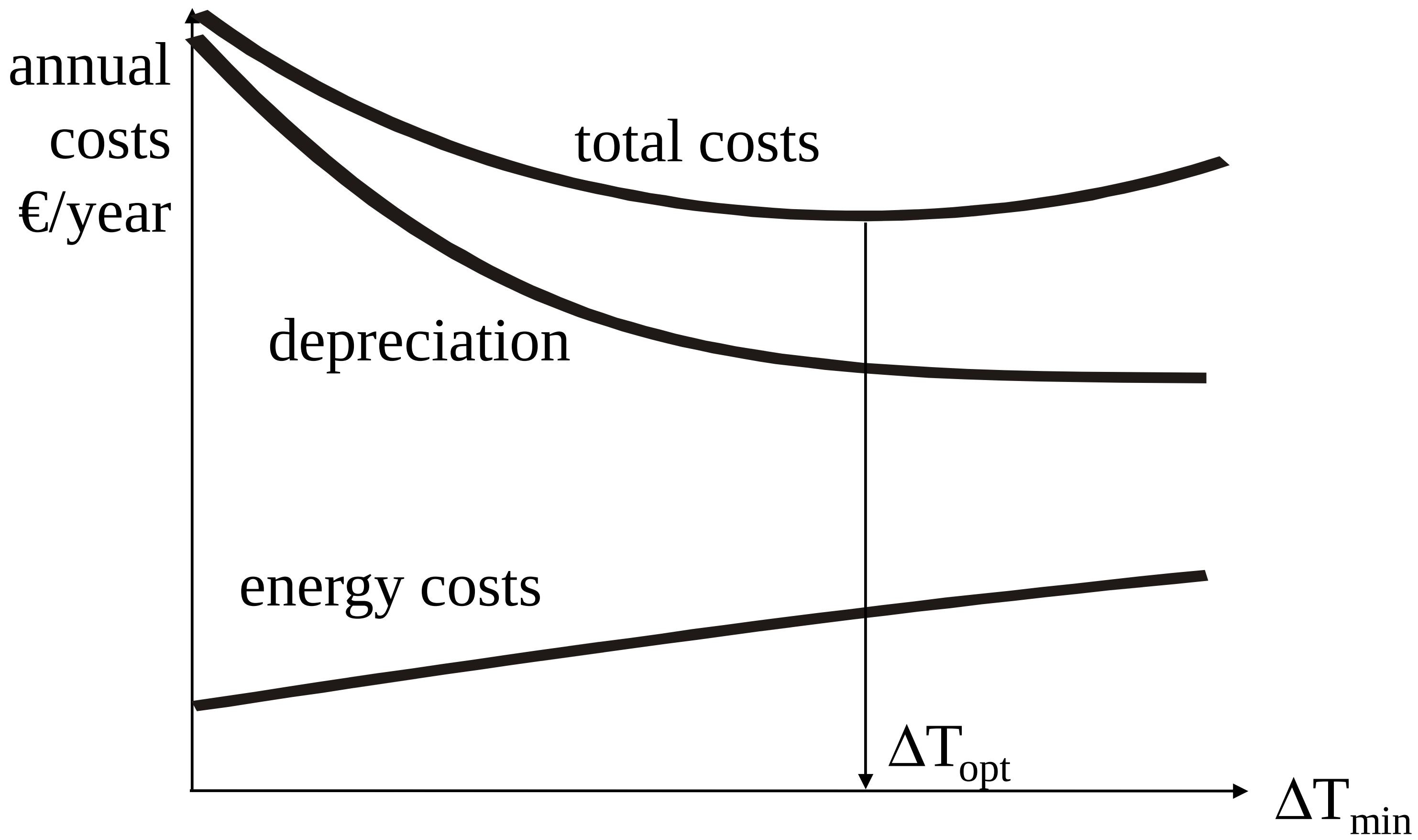
Matching the curves



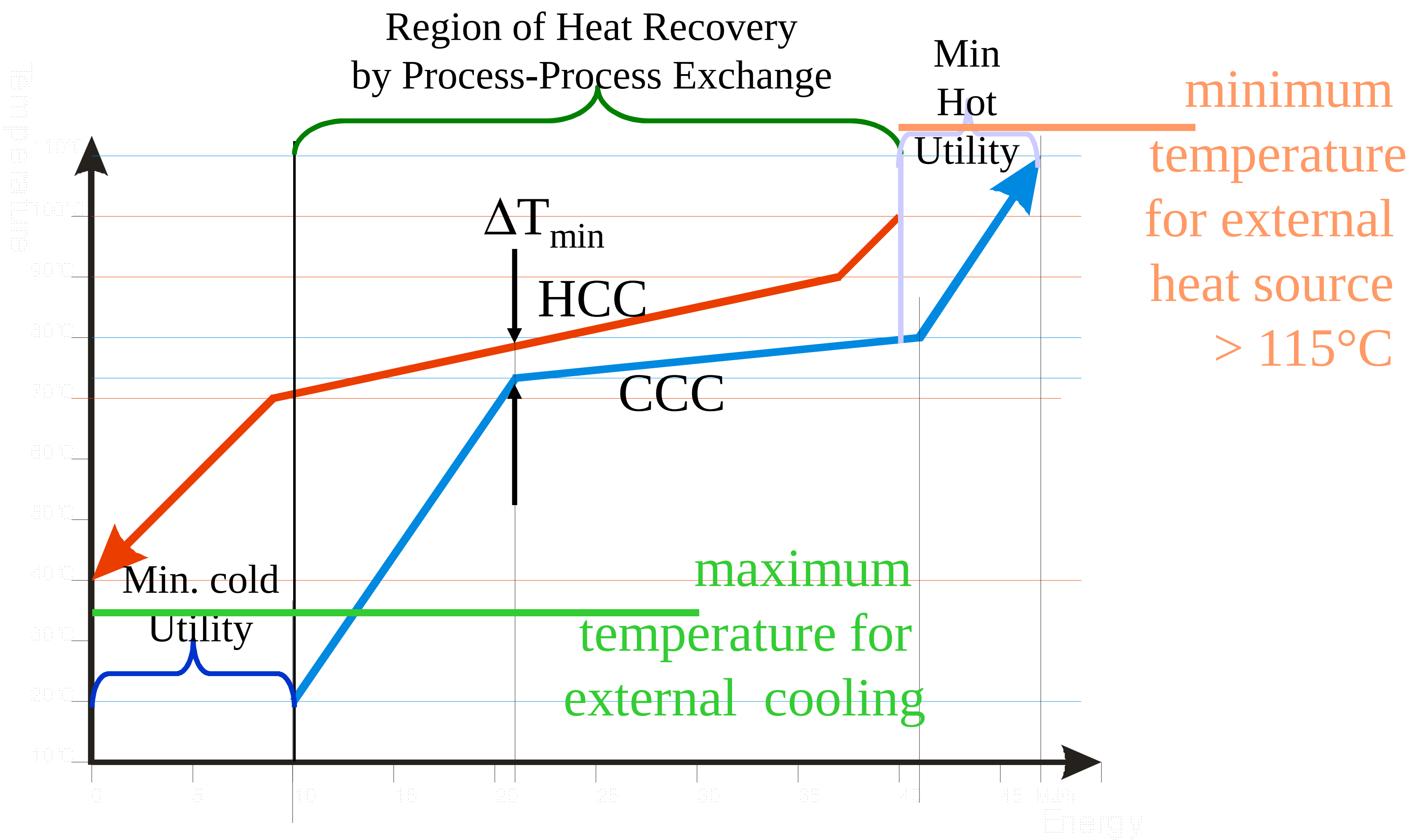
3 pinch design rules:

- no cold utility must be placed above the pinch
- no heat transfer must occur across the pinch
- no hot utility must be placed below the pinch

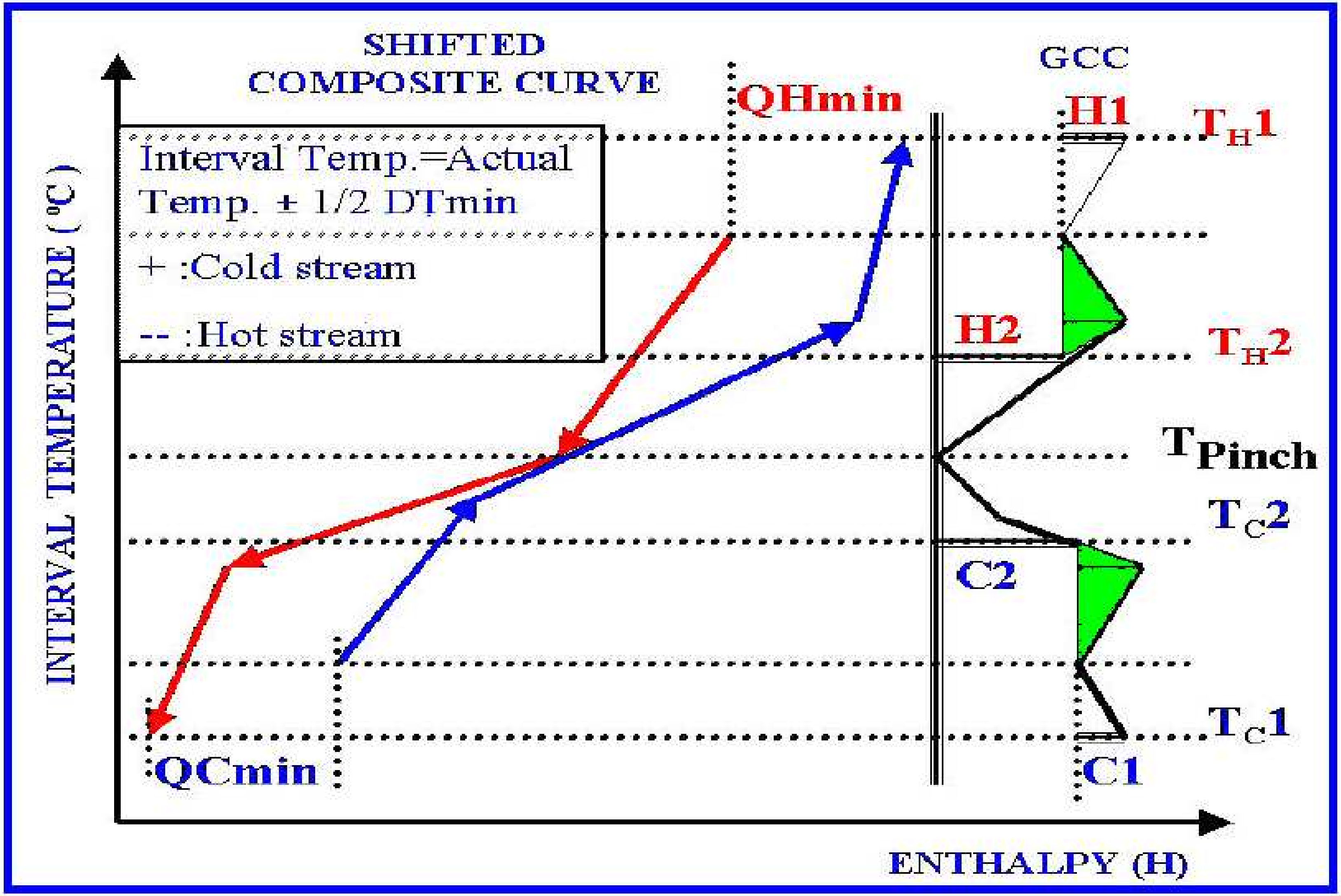
Find optimum ΔT



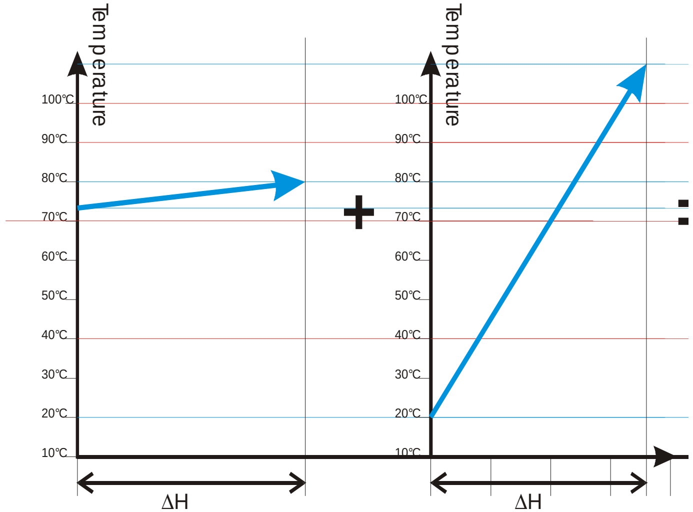
Temperature level of utilities



Grand Composite Curve



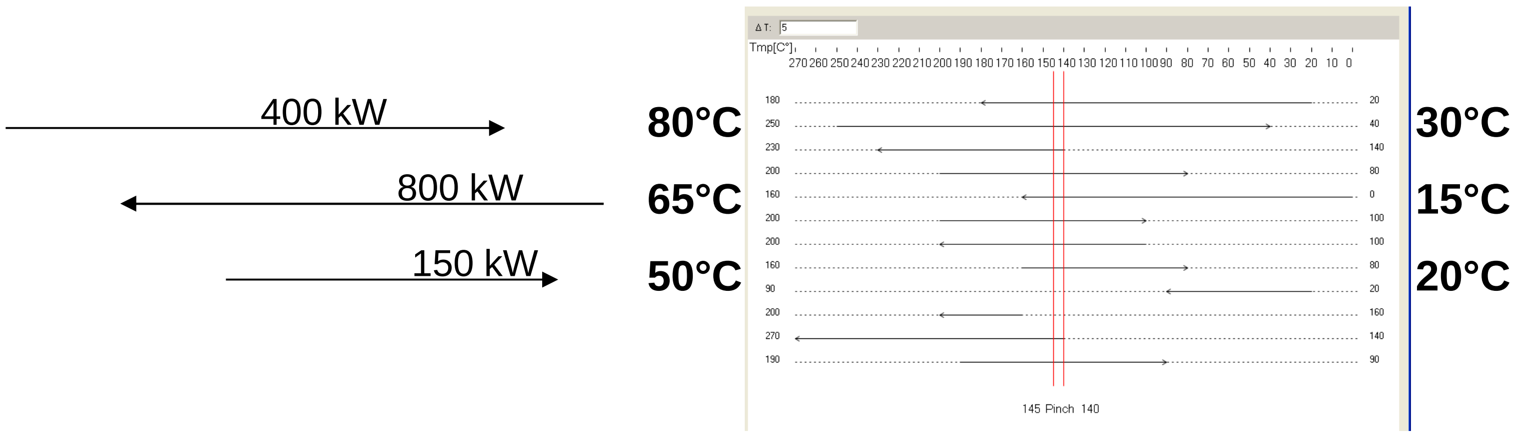
Temperature Grid Diagram



for each stream

- Start temperature - 20°C
- Target temperature - 65°C
- Heat load: m*cp*ΔT = H [kW]

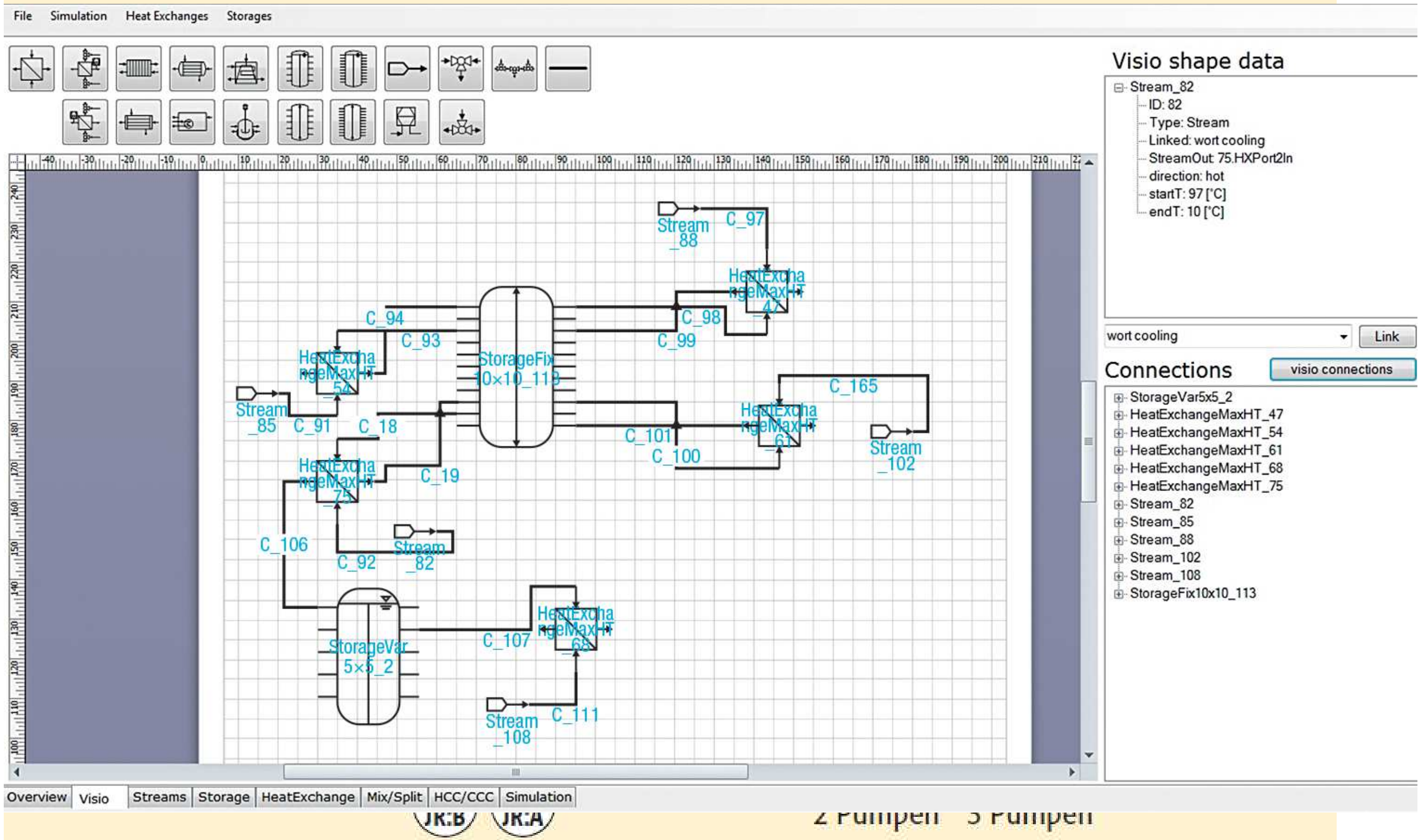
Each stream is displayed as a line in the temperature grid diagram:



Heat exchanger designs

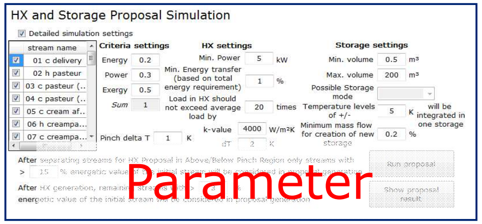
- **Designer rules**
  - ⇨ Right temperature
  - ⇨ Right power
  - ⇨ No heat exchange above the pinch
- **Heat exchanger calculation**
  - ⇨ Definition of temperature
  - ⇨ Definition of enthalpy
- **HEN criteria – cost savings**
  - ⇨ Maximal transfer with a minimum of investment costs
  - ⇨ Optimal thermodynamic use of streams under exergetic considerations

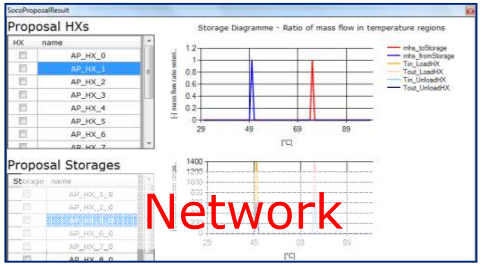
Advanced Pinch Tool - SOCO



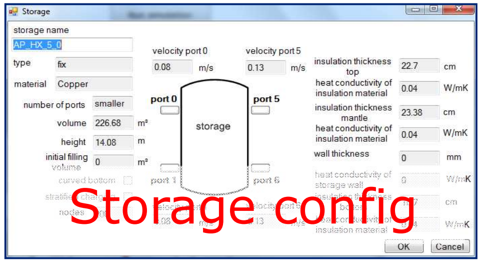
9461.2

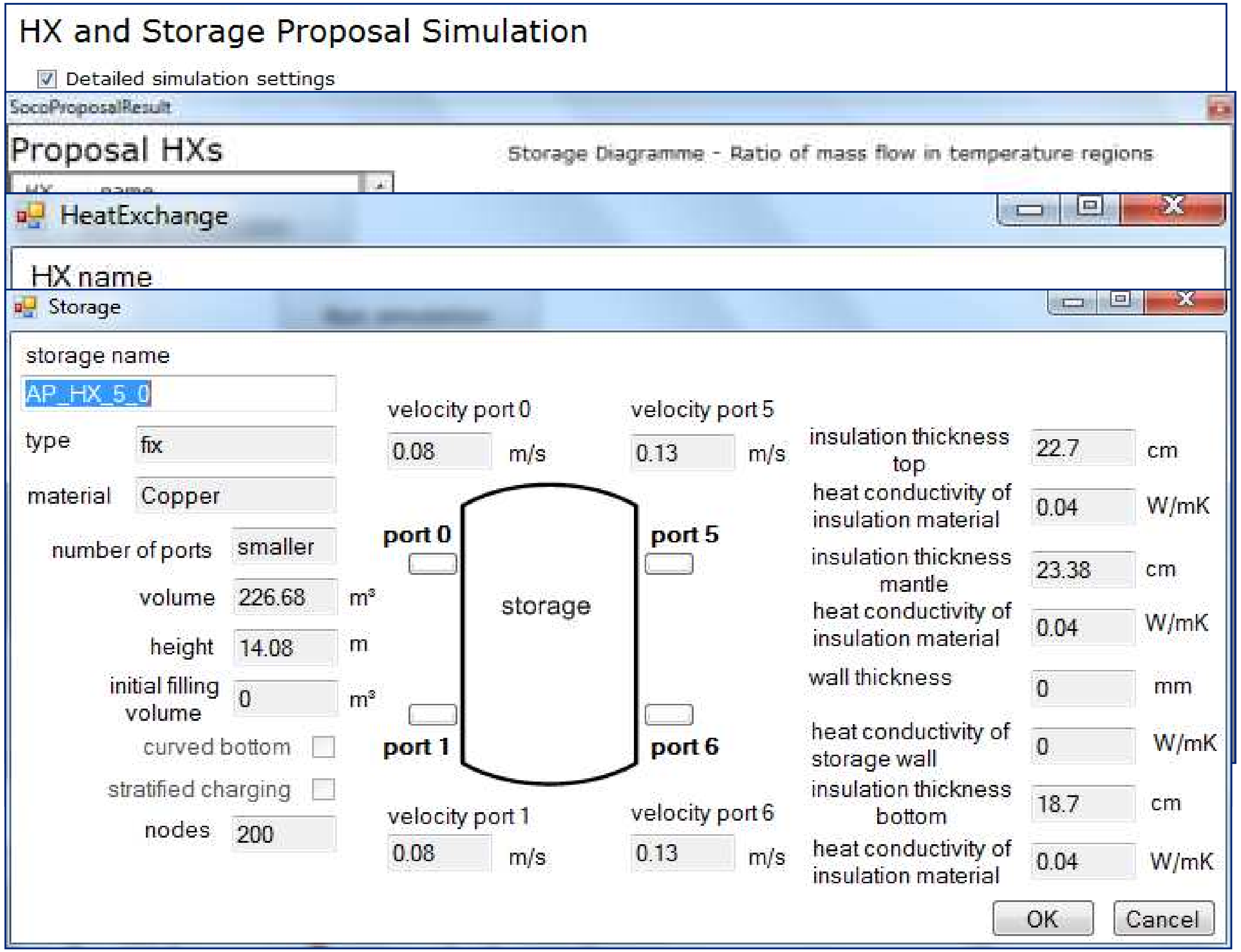
Proposal


HX and Storage Proposal Simulation
Parameter


Proposal HXs
Storage Diagramme - Ratio of mass flow in temperature regions
Proposal Storages
Network


HeatExchange
HX name
HEX config


Storage
storage name
Storage config


HX and Storage Proposal Simulation
Detailed simulation settings
SocoProposalResult
Proposal HXs
Storage Diagramme - Ratio of mass flow in temperature regions
HeatExchange
HX name
Storage
storage name
AP_HX_5_0
type
fix
material
Copper
number of ports
smaller
volume
226.68
m³
height
14.08
m
initial filling volume
0
m³
curved bottom
stratified charging
nodes
200
velocity port 0
0.08
m/s
velocity port 5
0.13
m/s
port 0
port 5
storage
port 1
port 6
velocity port 1
0.08
m/s
velocity port 6
0.13
m/s
insulation thickness top
22.7
cm
heat conductivity of insulation material
0.04
W/mK
insulation thickness mantle
23.38
cm
heat conductivity of insulation material
0.04
W/mK
wall thickness
0
mm
heat conductivity of storage wall
0
W/mK
insulation thickness bottom
18.7
cm
heat conductivity of insulation material
0.04
W/mK
OK
Cancel

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Simulation

SocoSimulationResult

Heat exchanges

name	transfer E. [kWh]	ratio per HX [%]
43	69512.5	7.1
259	101454	10.36
50	86737.69	8.85
57	163021.31	16.64
71	35998.24	3.67
97	120579.08	12.31
202	17853.37	1.82
162	22695.94	2.32
218	69521.88	7.1

Streams

reference T. 0 °C

name	avg. T [°C]	energy value [kWh]	ratio per stream [%]
65	140	484027.49	14.92
75	40	145622.4	4.49
89	48	158056.19	4.87
70	8	35180.31	1.08
85	6	19038.8	0.59
90	70	95521.94	2.95
108	70	222119.35	6.85
210	62.9	72367.44	2.23
198	12	23464	0.72

Storages

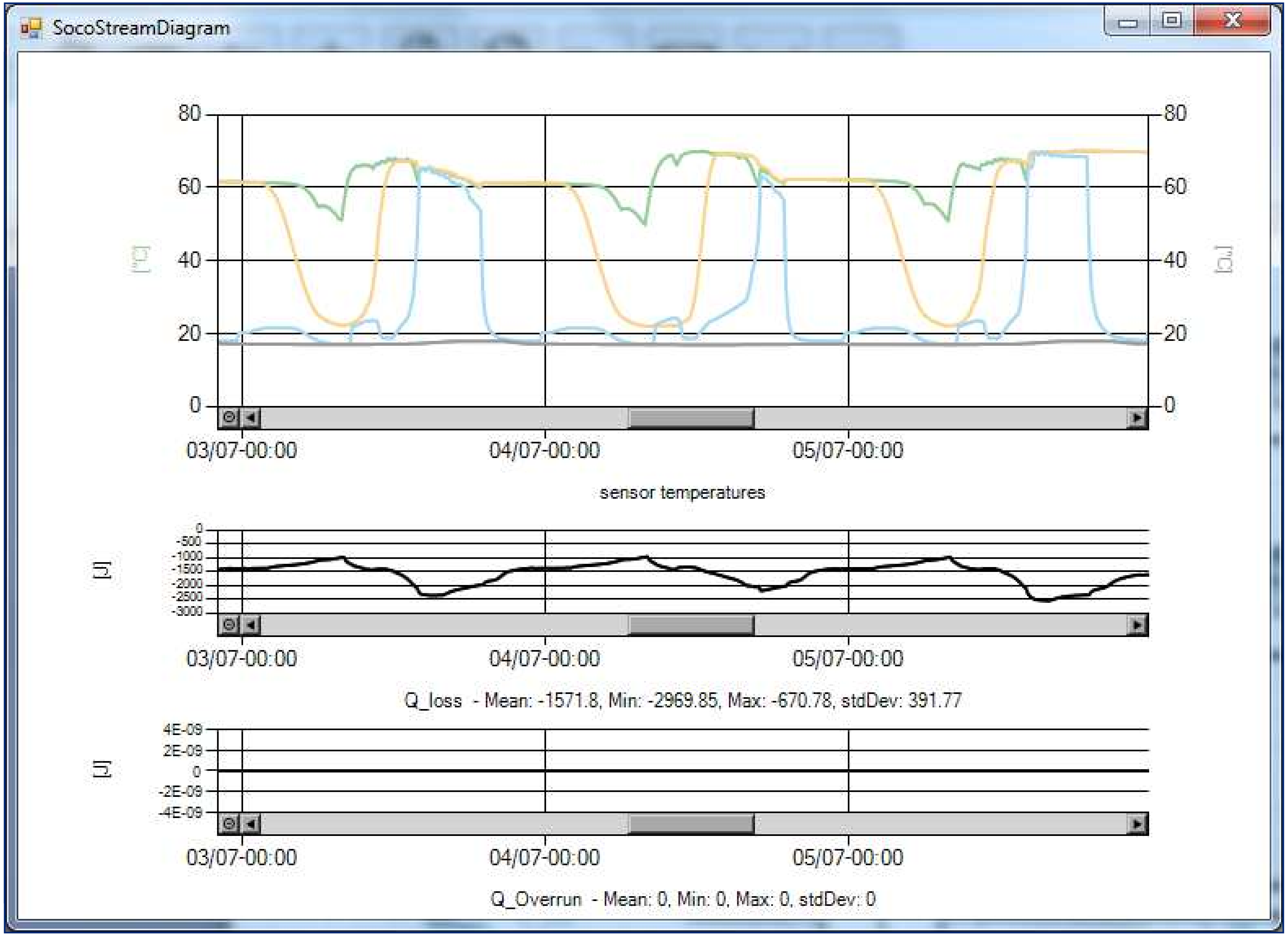
name	E. losses [kWh]	ratio E. losses [%]
StorageFix...	1278.66	0.01
StorageFix...	2431.26	0.02

Output streams (remaining energy demand)

name	direction	start T. [°C]	end T. [°C]	remaining E. demand [kWh]
HX_ID_43_...	hot	20.91	8	46985.42
HX_ID_57_...	cold	80.6	81.5	3947.56
HX_ID_97_...	hot	32	32	0
HX_ID_109...	cold	63.68	70	20053.85
HX_ID_122...	hot	66.43	60	22243.93

utility demand	avg. T [°C]	max. T [°C]	min. T [°C]	energy [kWh]
heating demand	60.8	102		74257.23
cooling demand	28.99		5	290127.96

Simulation of storage and heat exchanger

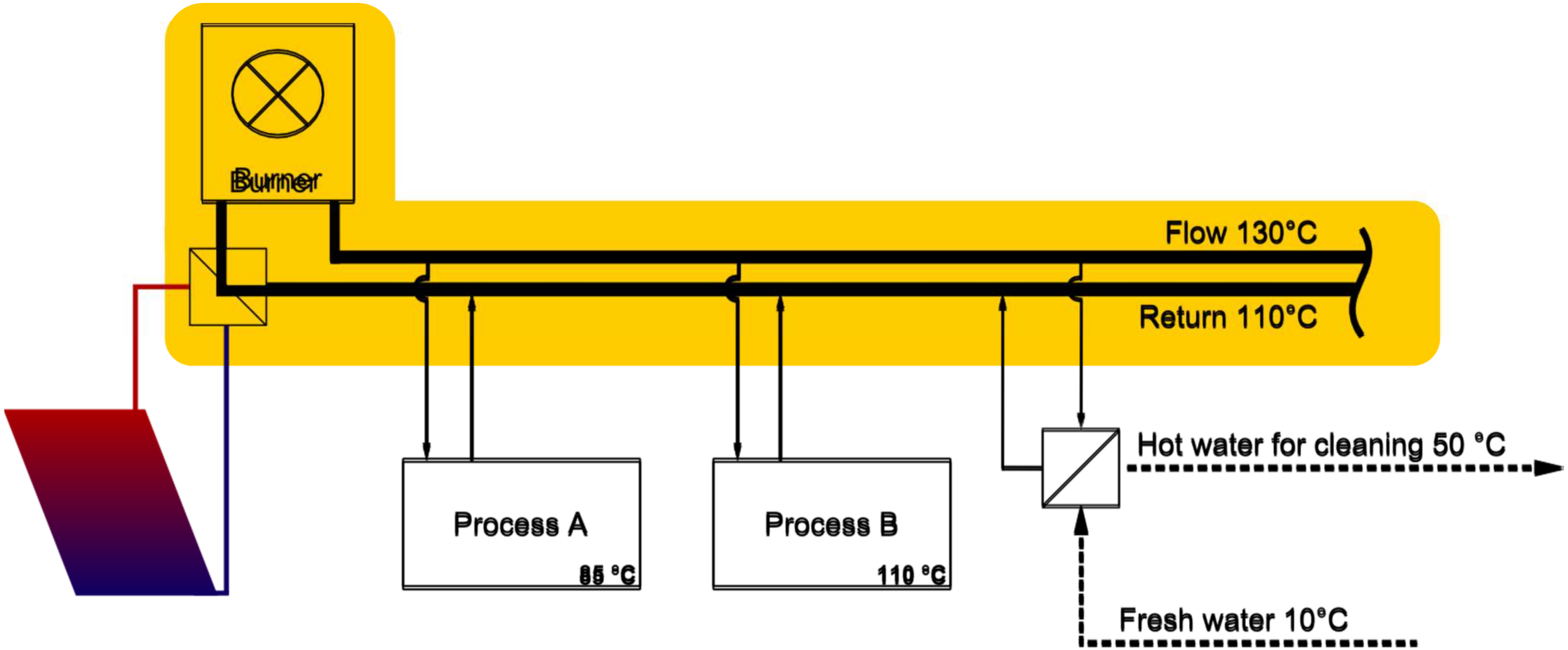


Principles of system integration

Supply level

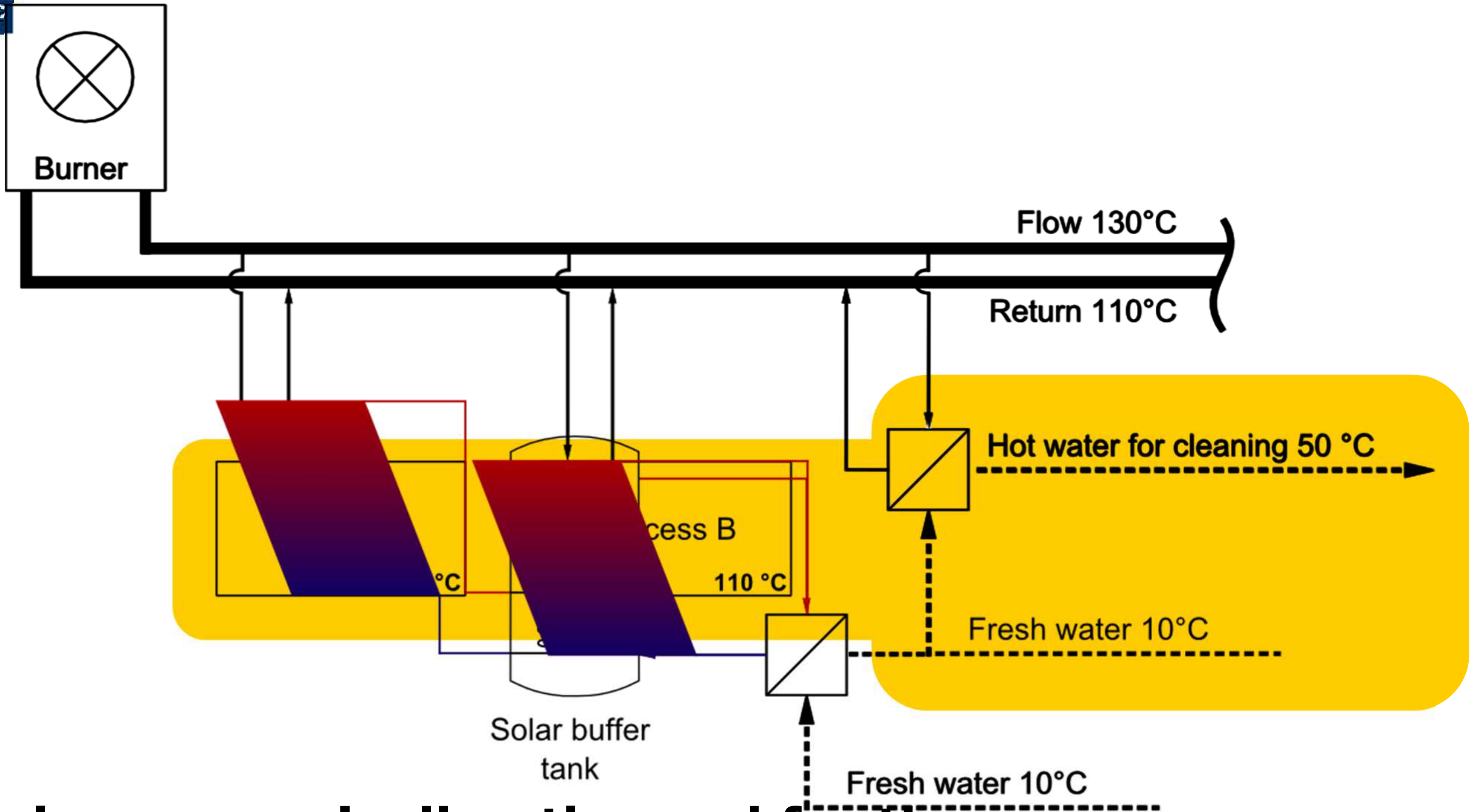
Process level

Integration on supply level – hot water

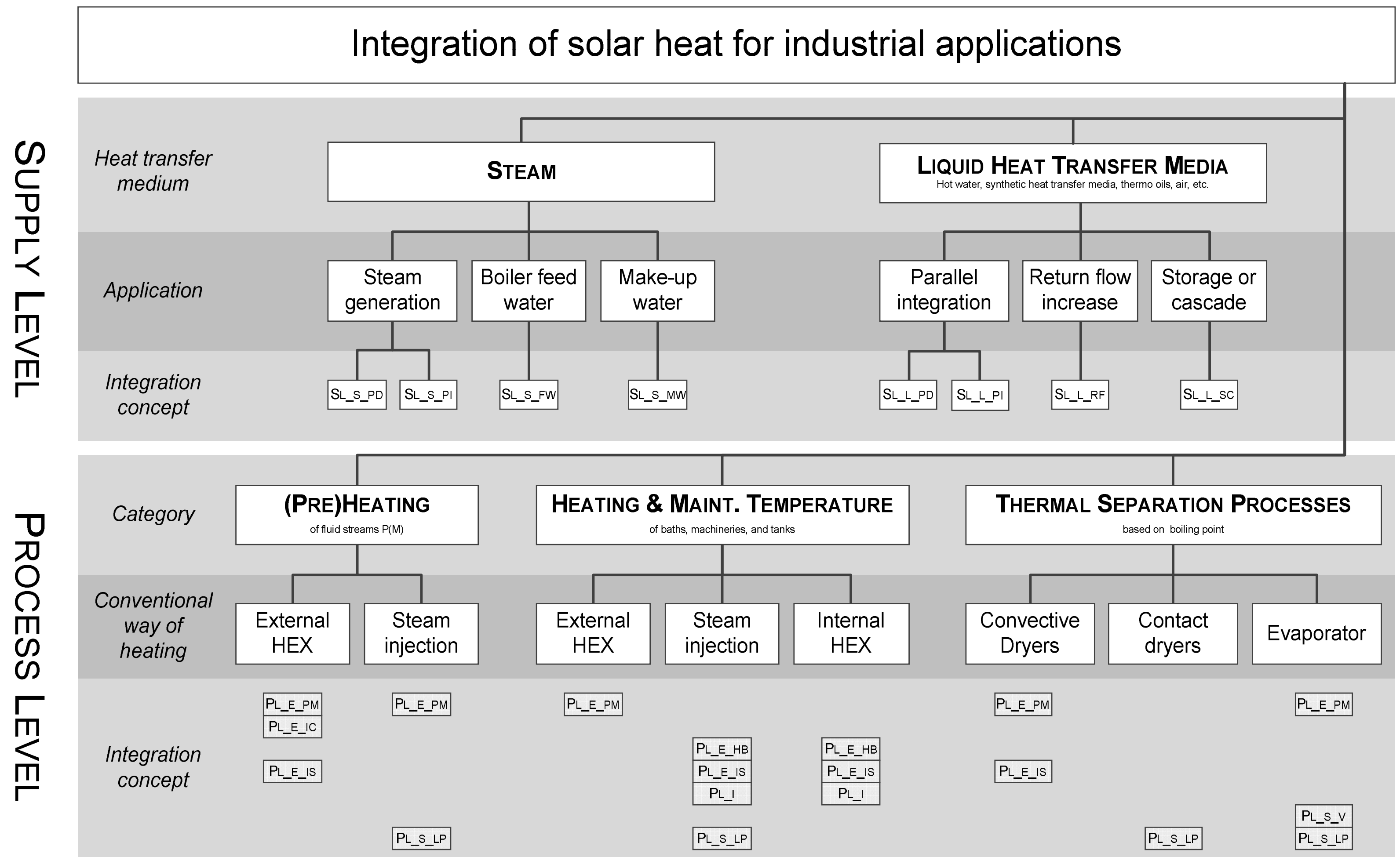


- Feed-in solar energy in heating circuit
- High set temperature
- Simple system integration
- Small number of system layouts

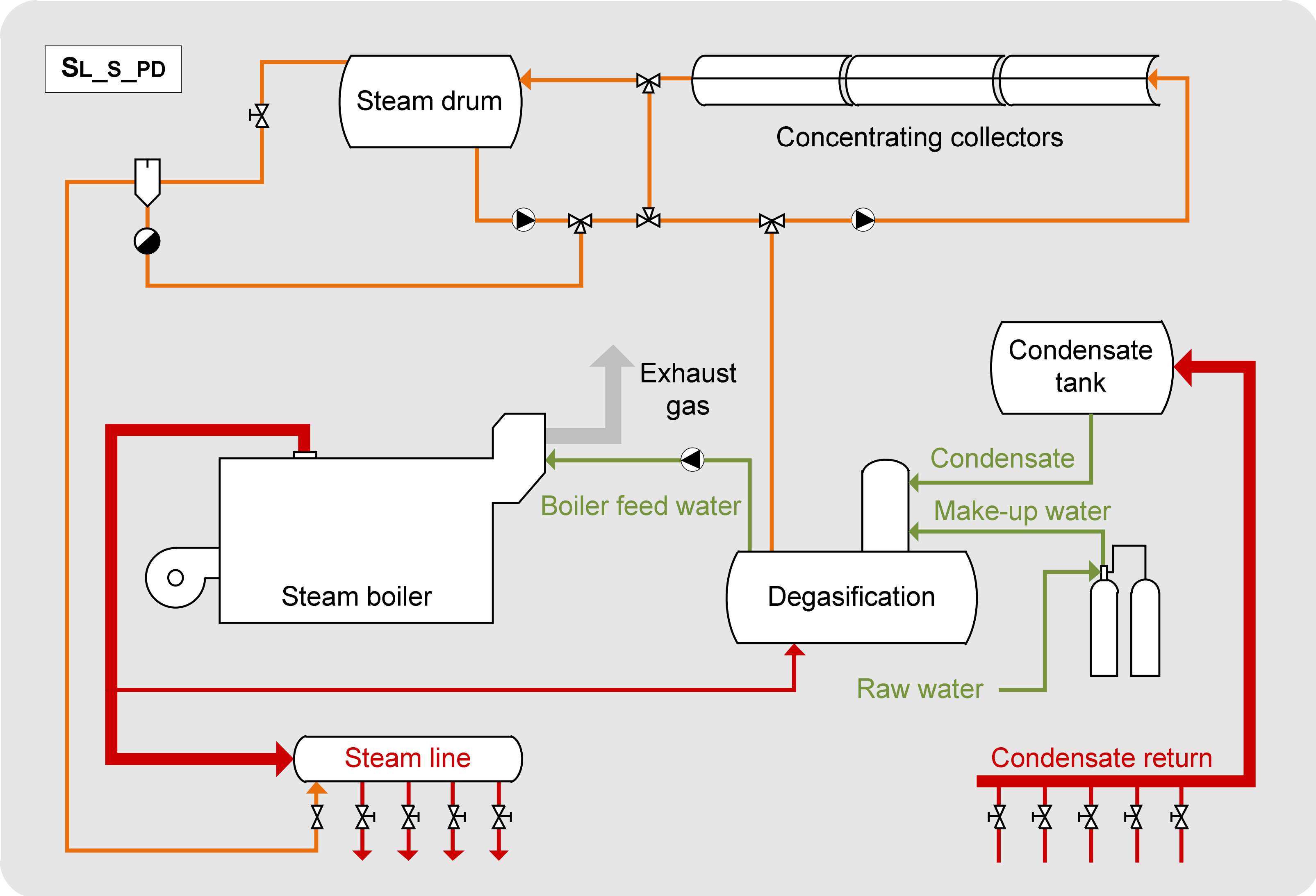
Integration on process level



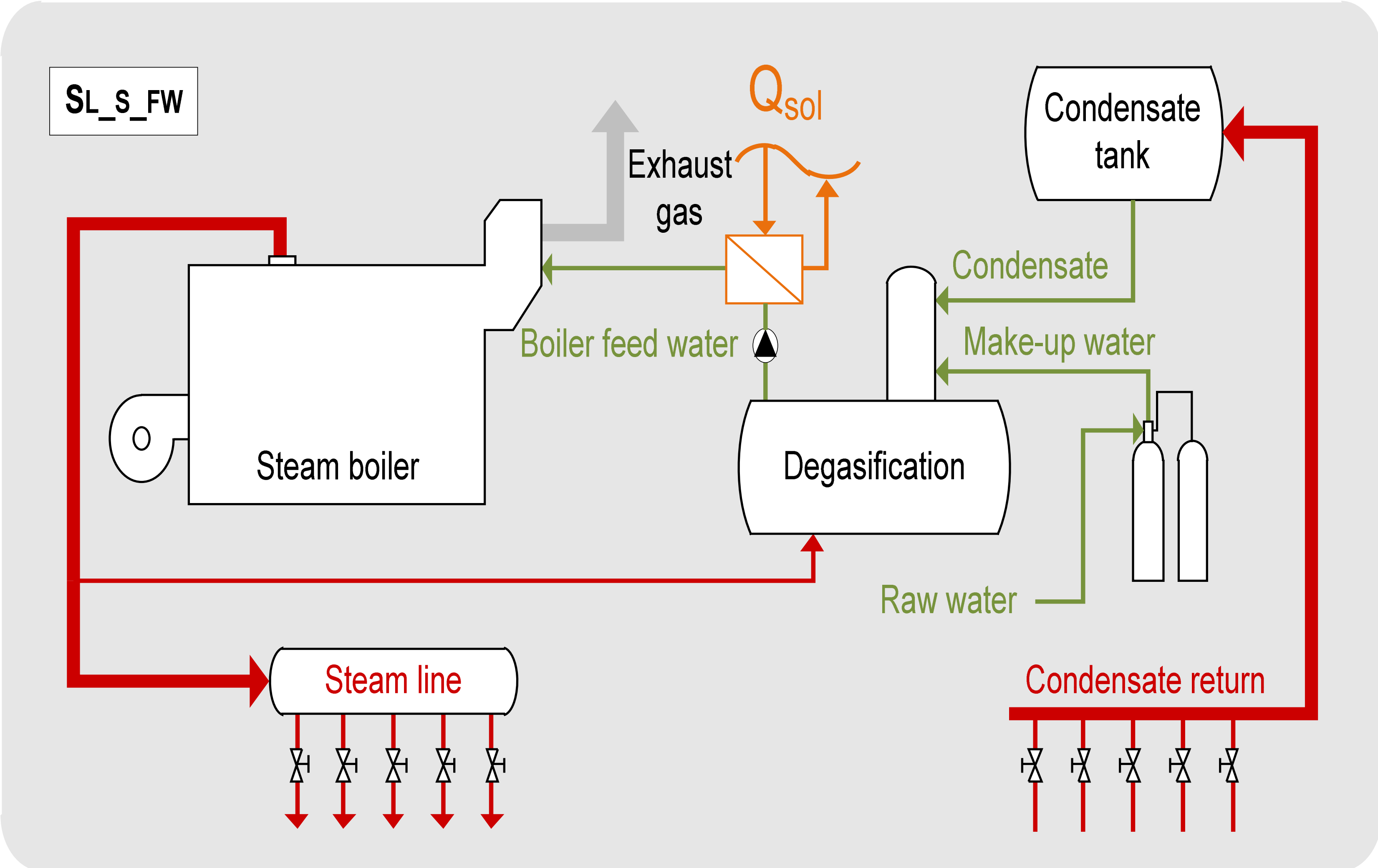
- Solar energy is directly used for the process
- Different system layouts possible
- Often complex system integration


Integration of solar heat for industrial applications
SUPPLY LEVEL
Heat transfer medium
Application
Integration concept
STEAM
LIQUID HEAT TRANSFER MEDIA
Hot water, synthetic heat transfer media, thermo oils, air, etc.
Steam generation
Boiler feed water
Make-up water
Parallel integration
Return flow increase
Storage or cascade
SL_S_PD
SL_S_PI
SL_S_FW
SL_S_MW
SL_L_PD
SL_L_PI
SL_L_RF
SL_L_SC
PROCESS LEVEL
Category
Conventional way of heating
Integration concept
(PRE)HEATING
of fluid streams P(M)
HEATING & MAINT. TEMPERATURE
of baths, machineries, and tanks
THERMAL SEPARATION PROCESSES
based on boiling point
External HEX
Steam injection
External HEX
Steam injection
Internal HEX
Convective Dryers
Contact dryers
Evaporator
PL_E_PM
PL_E_IC
PL_E_IS
PL_E_PM
PL_S_LP
PL_E_PM
PL_E_HB
PL_E_IS
PL_I
PL_S_LP
PL_E_HB
PL_E_IS
PL_I
PL_E_PM
PL_E_IS
PL_S_LP
PL_E_PM
PL_S_V
PL_S_LP

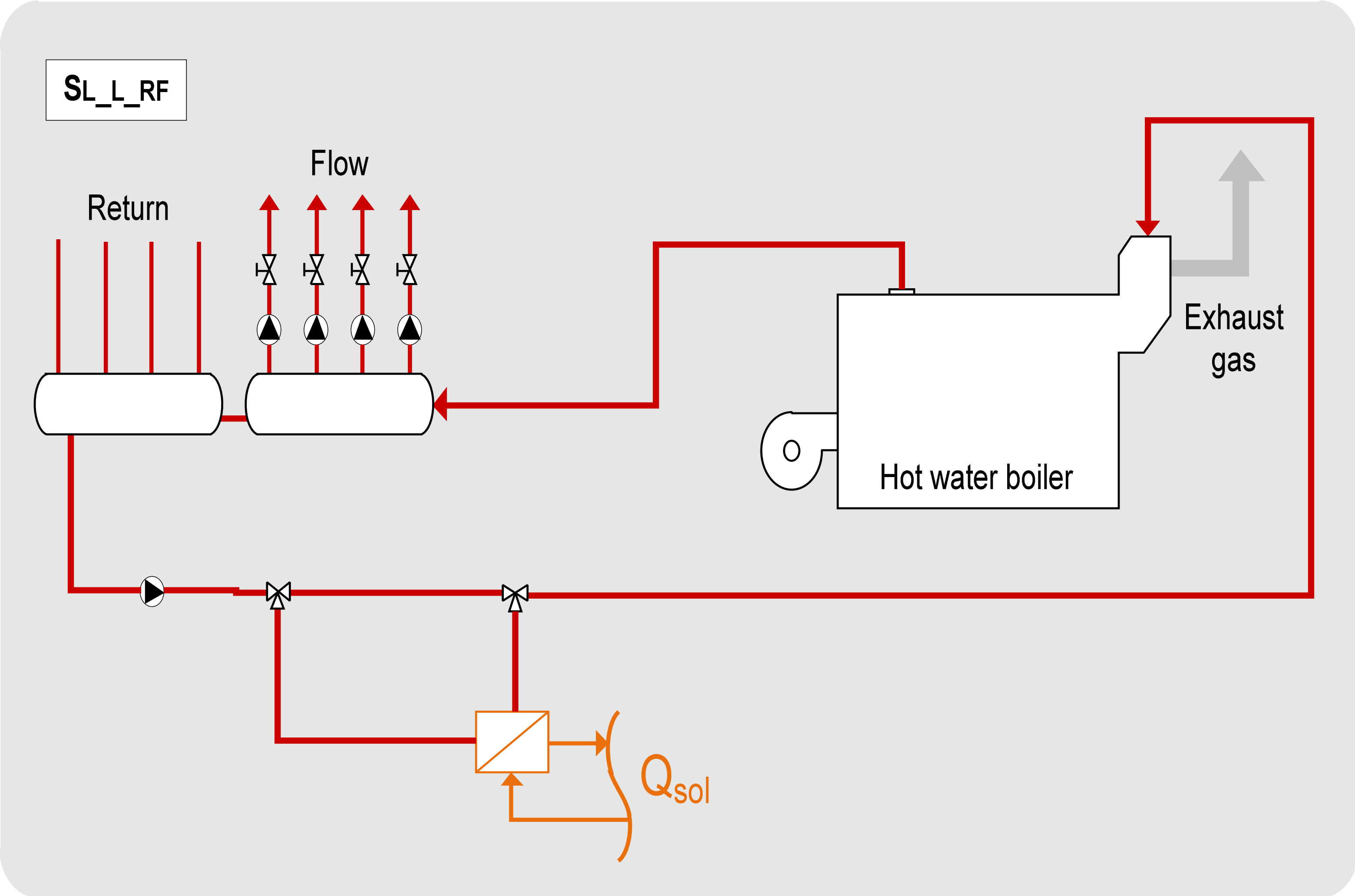
Direct steam



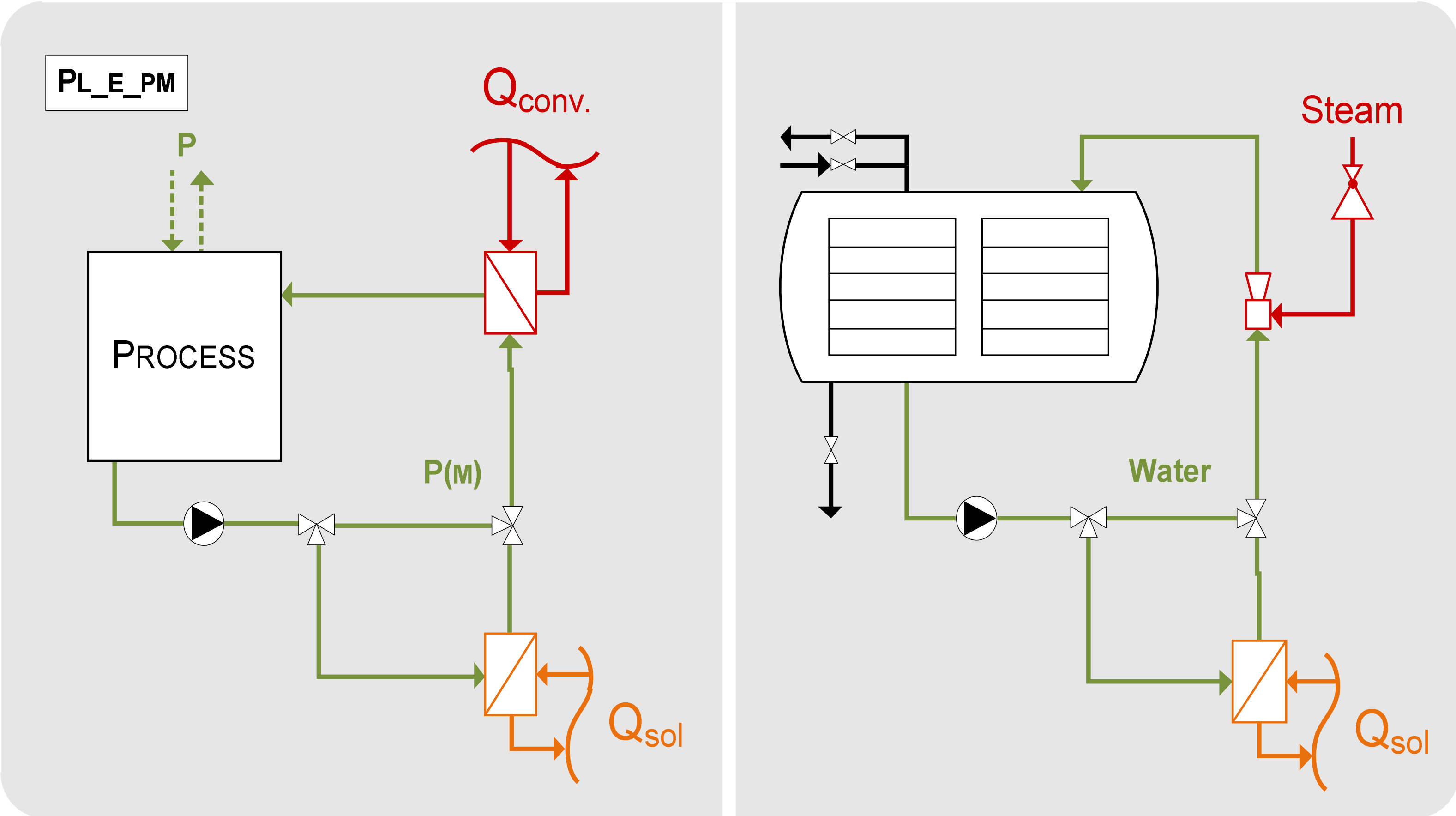
Pre heating boiler feed water



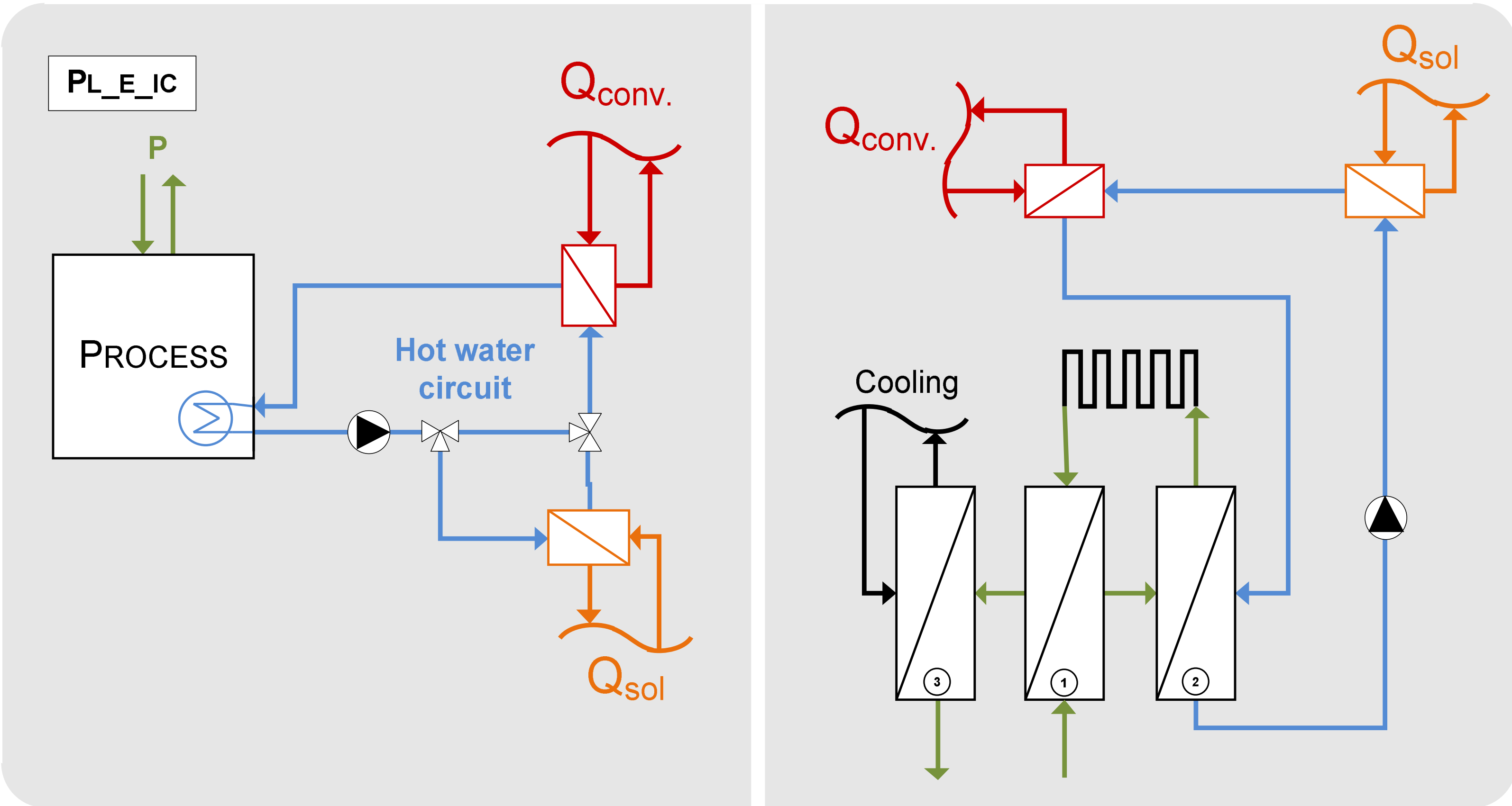
serial integration at supply level with liquid heat transfer media



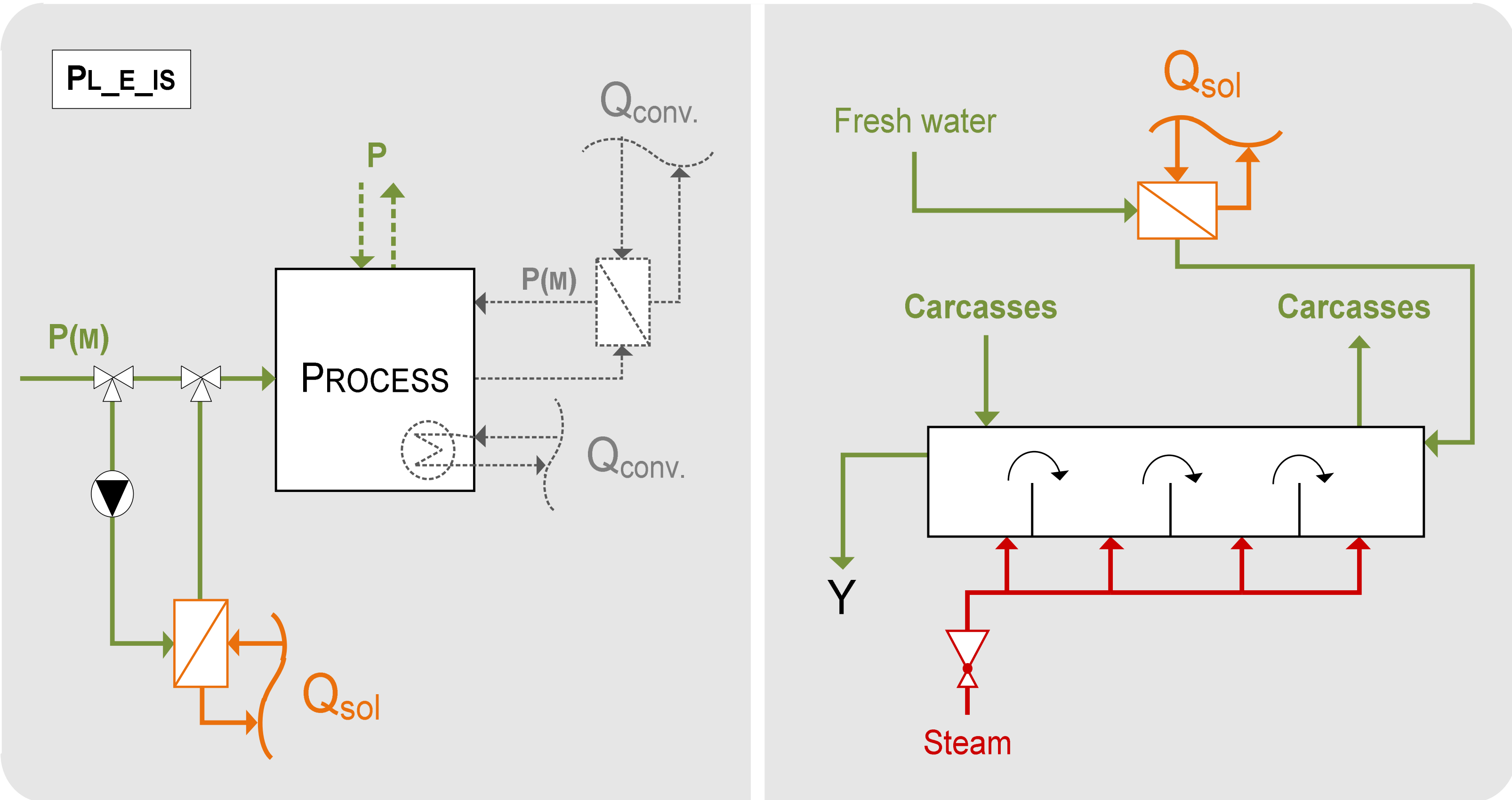
solar heating of product or process media with external heat exchanger General integration flow sheet (left) and illustrated by sterilization process with autoclave (right)



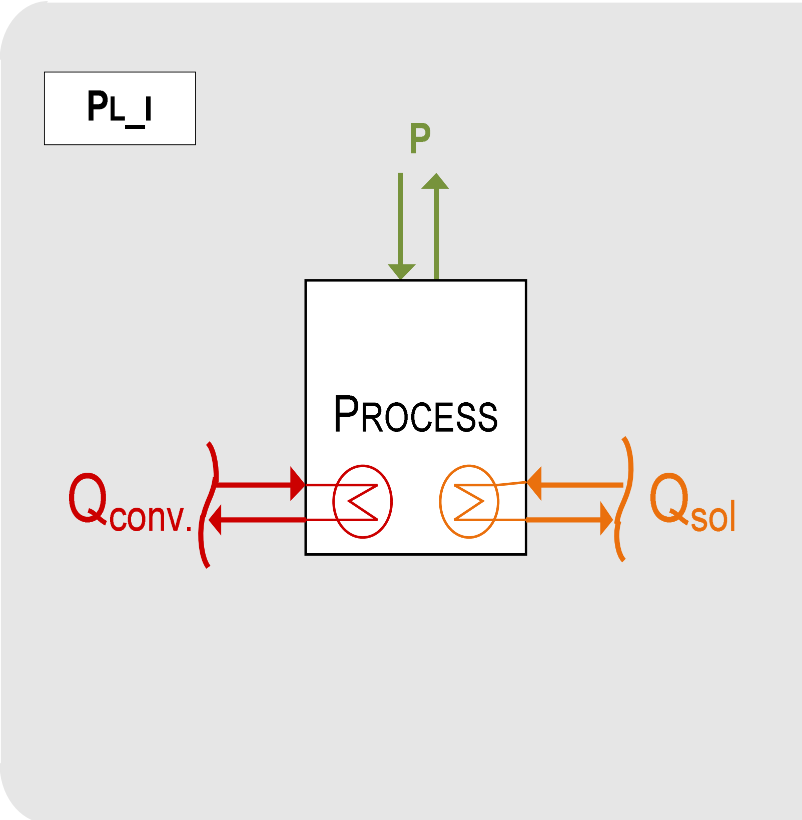
of intermediate hot water circuits with external heat exchanger General integration flow sheet (left) and illustrated by pasteurization process with multi zone plate heat exchanger and external heating zone (right).

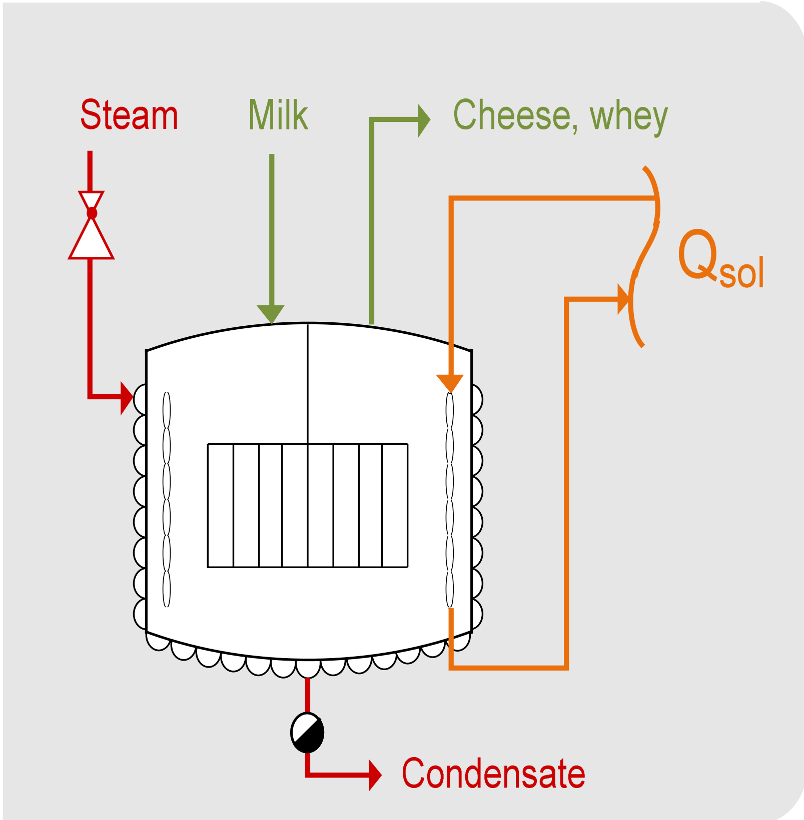


bath, machinery or tank with external heat exchanger General integration flow sheet (left) and illustrated by scalding process for chicken slaughtering heated via direct steam injection (right).

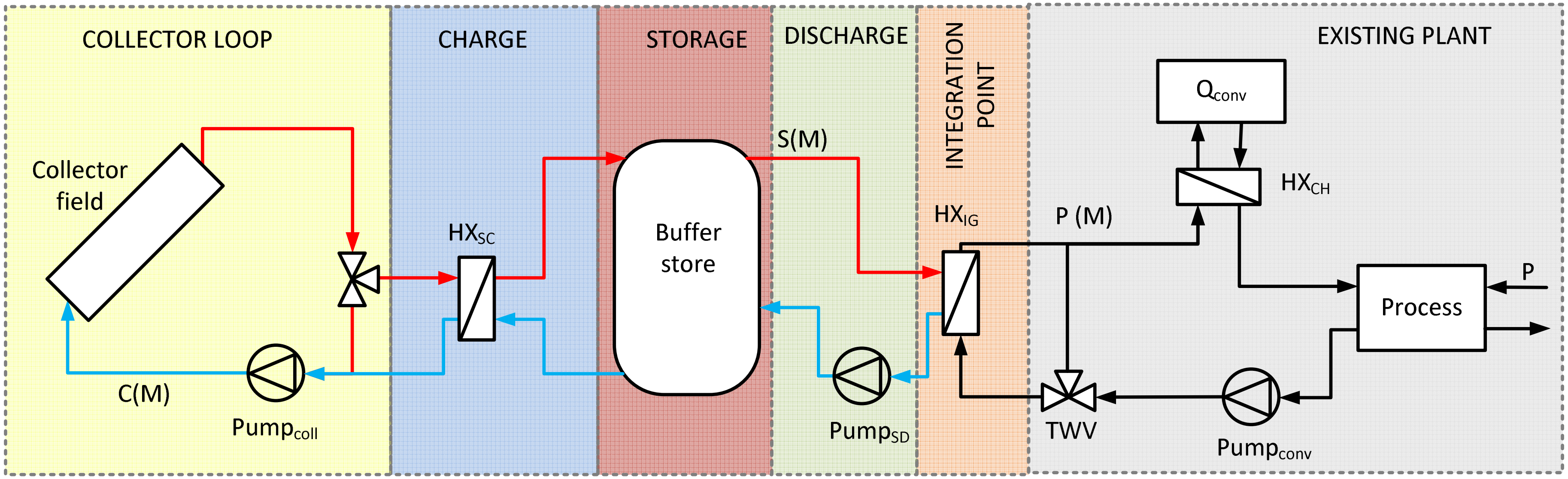


solar heating of bath, machinery or tank with internal heat exchanger General integration flow sheet (left) and illustrated by curd vessel for cheese production heated with conventional heating jacket and additional solar driven dimple plates (right).

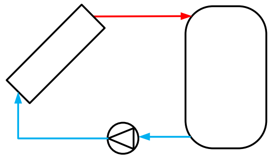
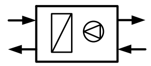
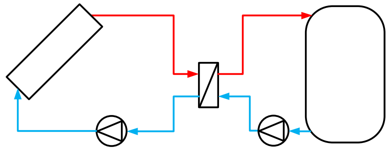
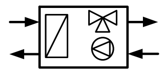
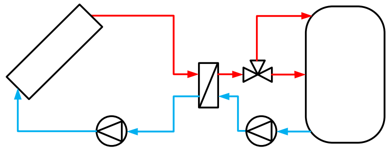
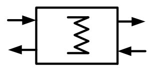
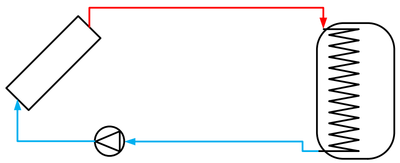
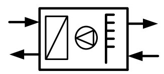
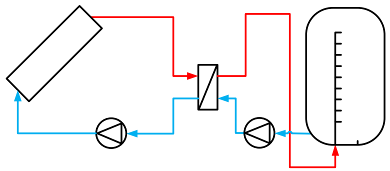


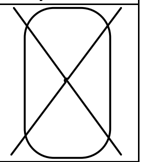
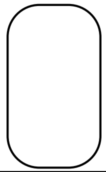
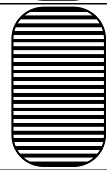
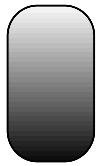
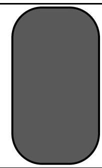


Subdivision of a solar process heat system exemplary for integration point



Storage systems

Description	Symbol	Equivalent system scheme
D – direct charging without **heat exchanger**		
E - external heat exchanger and charging pump (two different media in solar field and storage) Pros: collectors can be operated with glycol mixture Cons: single inlet height may damage stratification		
EV - external heat exchanger and valve and charging pump. Inlet height in storage control by temperature (two different media in solar field and storage) Pro : simple design, robust, better stratification Pros: Cons:		
Less common concepts		
I - Internal heat exchanger (two different media in solar field and storage) Pros: Cons:		
L - heating lance (stratification device) Pros: good stratification		

Description	Symbol
• No storage	
Water Storage • Most common • Stores sensible heat • Can be operated up to 95 °C • Can be easily stratified	
Pressurized Water Storage • Stores sensible heat • Can be operated above 95 °C • More expensive	
Phase Change Material Storage • Stores latent heat • High heat capacity • Optimal operating point depends on the materials phase change point. • Highly expensive • Prototype stadium	
Solid State Storage • Used for air systems • High heat capacity • Complicated heat transmission towards full charge state	

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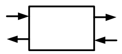
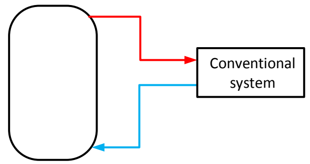
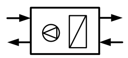
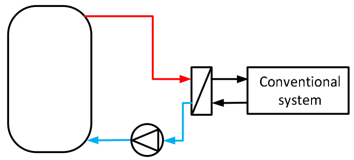
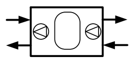
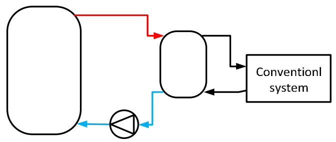
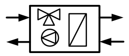
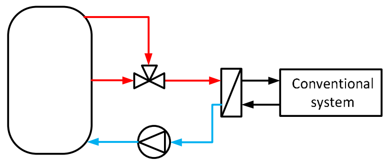
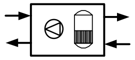
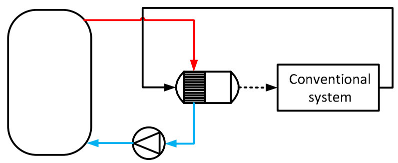
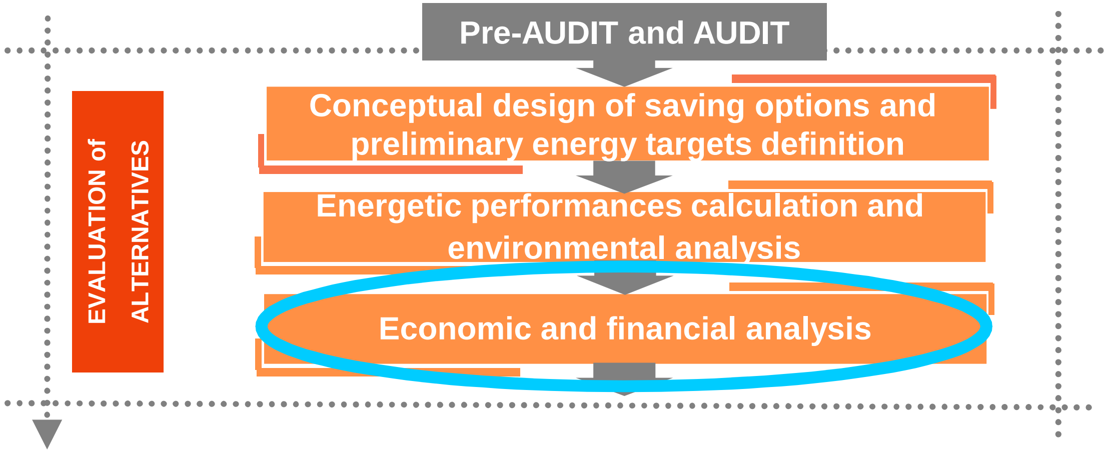
Description	Symbol	System scheme
Direct discharge • Storage medium is process medium • Storage is integration point		
Indirect discharging (• two different media in solar field and storage) via internal heat exchanger (integration point) and discharging pump		
Buffer storage and Batch pre-heating storage in parallel • Pump forces circulation between storages Optimal for batch processes with high mass flow		
E -Indirect discharge with three way valve two different media in solar field and storage via external heat exchanger(integration point)and discharging pump		
Discharging via evaporator • for pressurized storages evaporator is integration point		

EVALUATION OF ALTERNATIVES: STEP 9



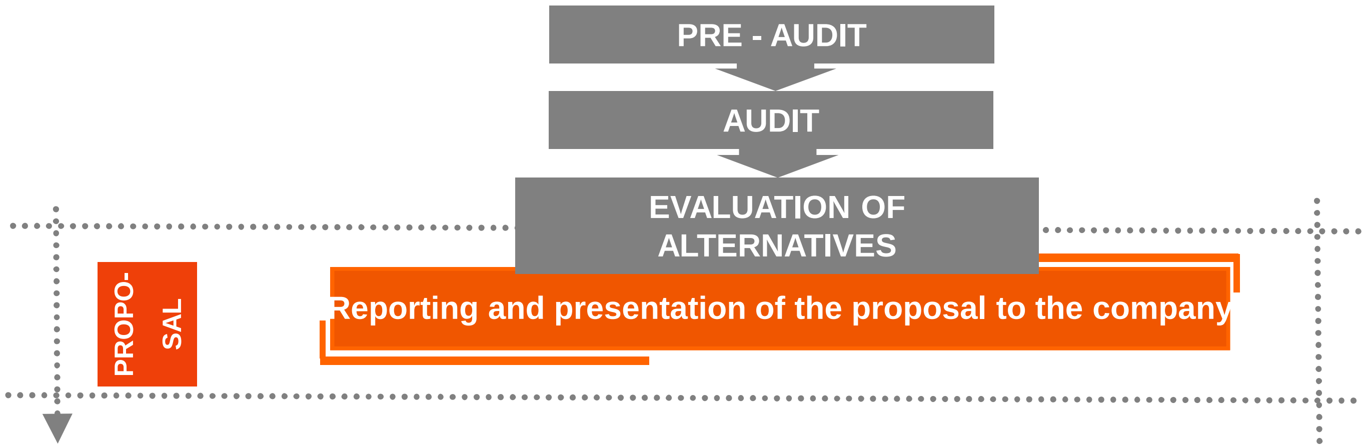
EINSTEIN Step 9: Economic and financial analysis

> calculate main economic parameters

> assess possibilities of funding and financing

> elaborate an appropriate financing scheme

PROPOSAL:
STEP 10



EINSTEIN Step 10: reporting and presentation to the company

> elaborate short-and-clean audit report

>present to the company

Follow-up
From the audit to the installation of a new system

- **Follow-up is as important as audit itself !**

- **Objective**
  - ⇨ Try to convince the company to realise the proposed investment and install new energy efficient systems
  - ⇨ If your proposals are realised: compare your predictions with the real behaviour

- **Learn also from negative responses: call and try to get information why your proposal was not realised**

Practical work

- Go through check list and collect company data
- Fill in questionnaire
- Draw flow sheet
- Identify missing data
- Select important data
- Plan for missing data acquisition
- Process optimisation
- System optimisation
- Efficient and renewable supply

Solar thermal Integration into industrial Processes

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