INDUSTRIAL HEAT+POWER 12,13,14 OKT. 2021 BRABANTHALLEN

Industrial Steam Vapor Recompression Heatpump

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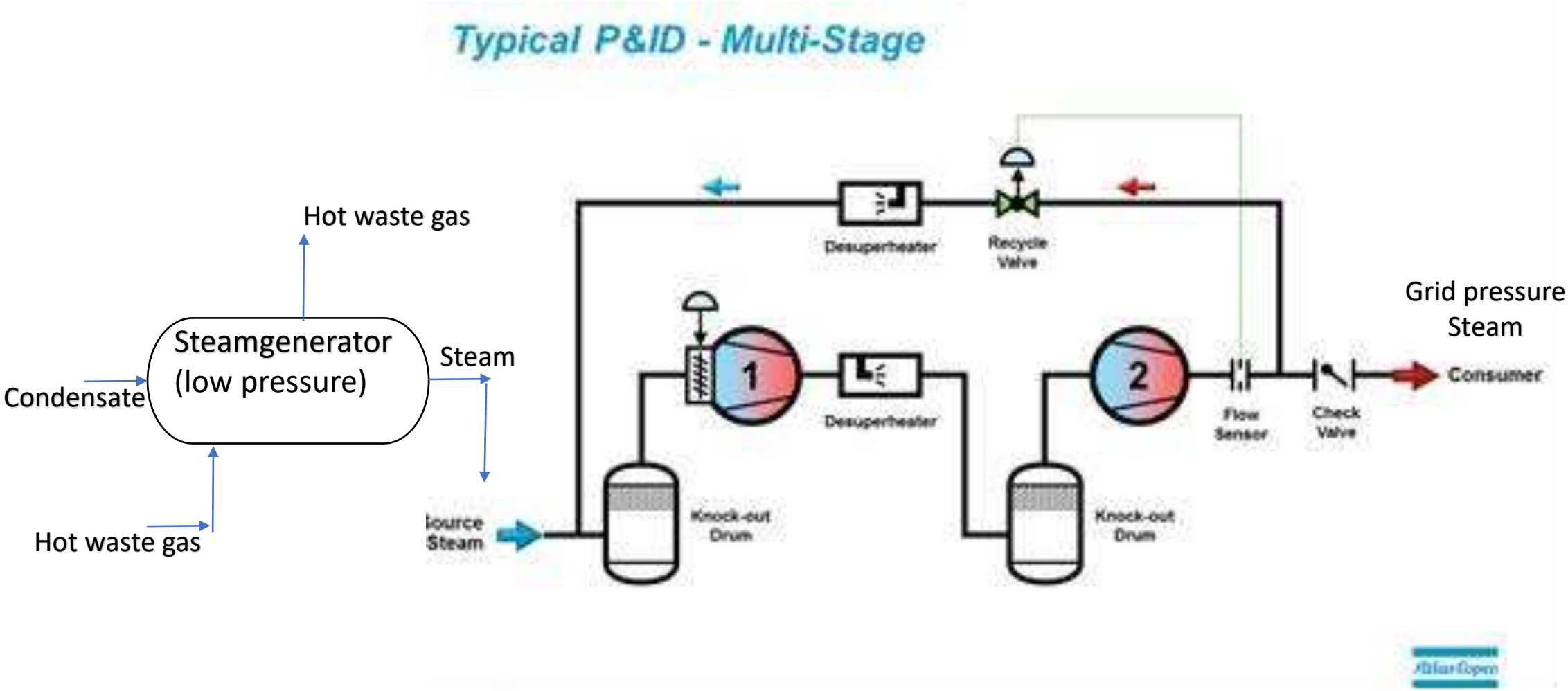
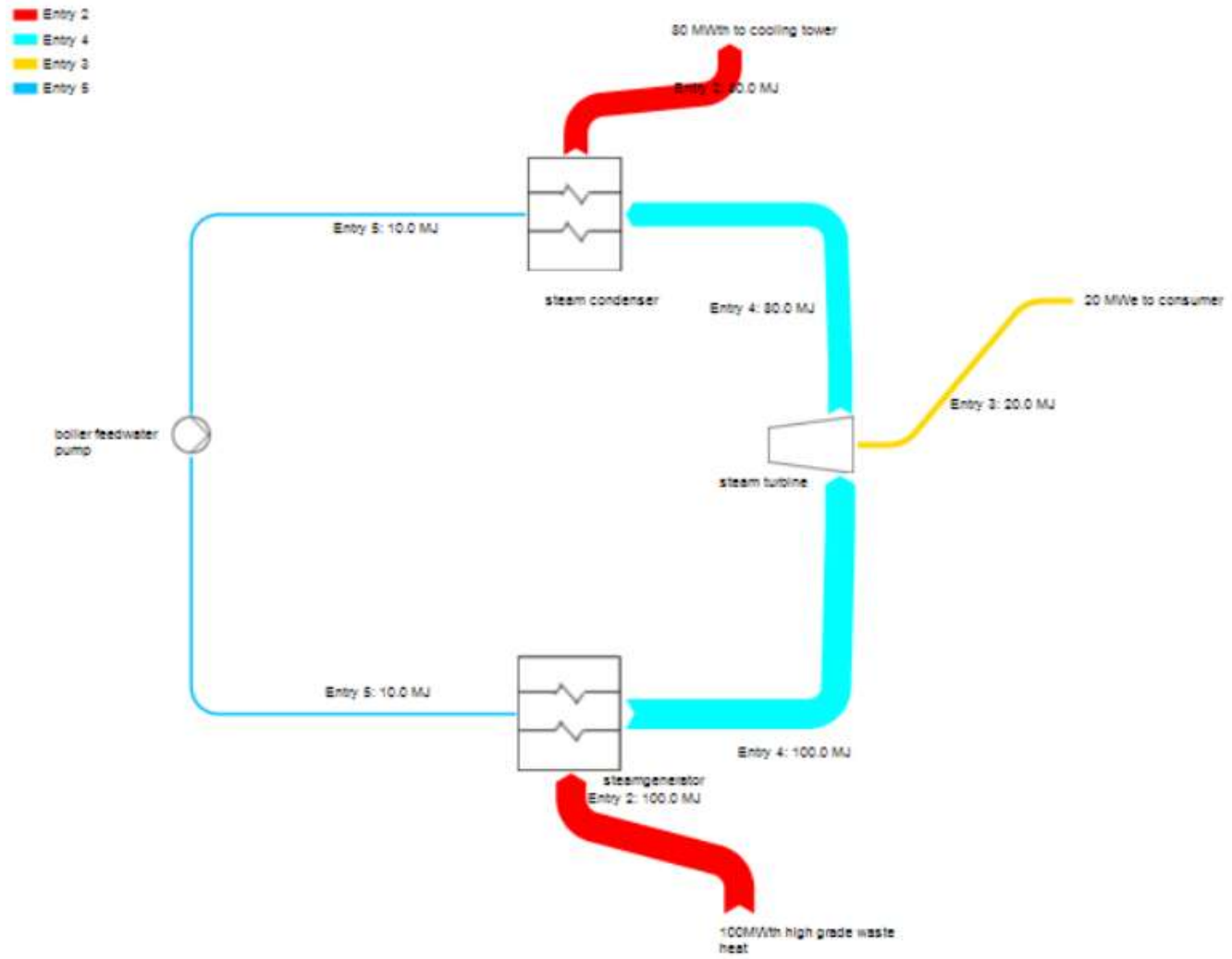
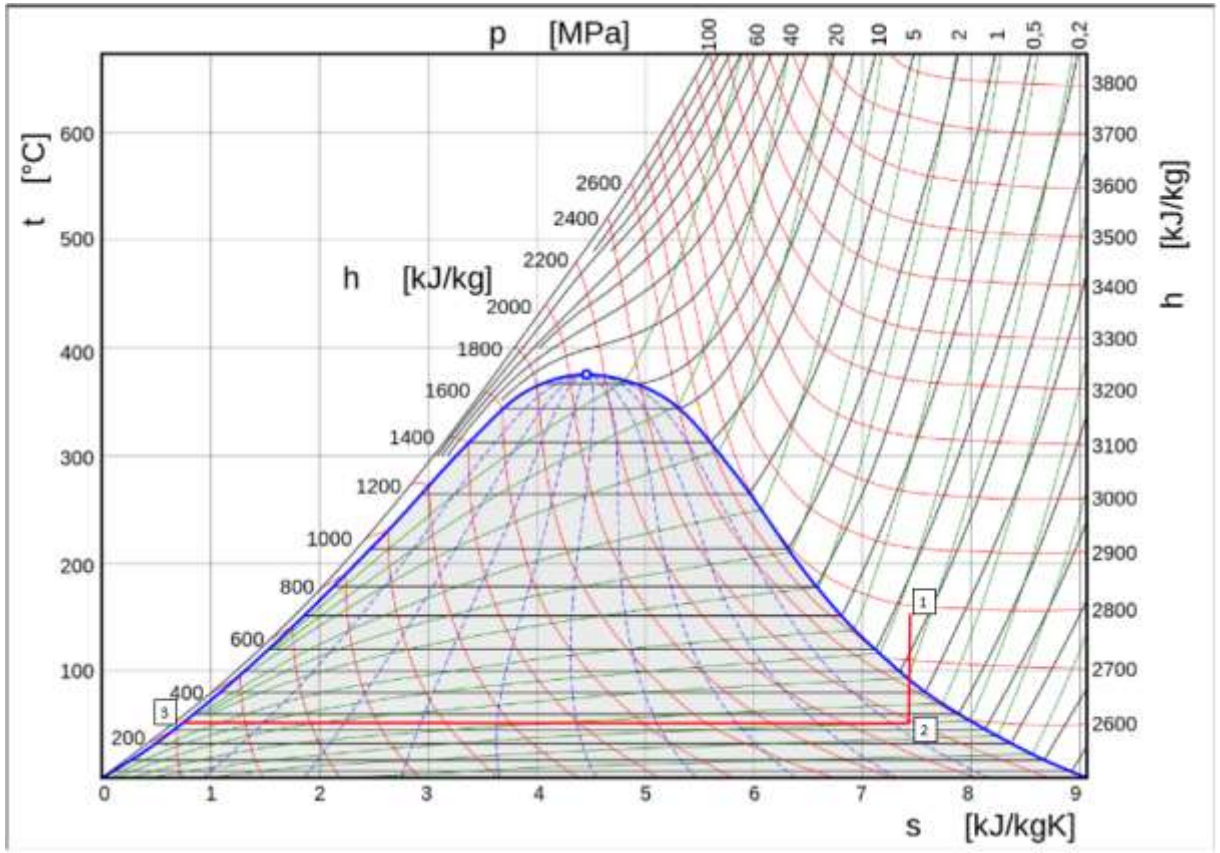
Typical P&ID MVR with permission from Atlas Copco



heat to power with carnot efficiency of 13 % (work / heat)



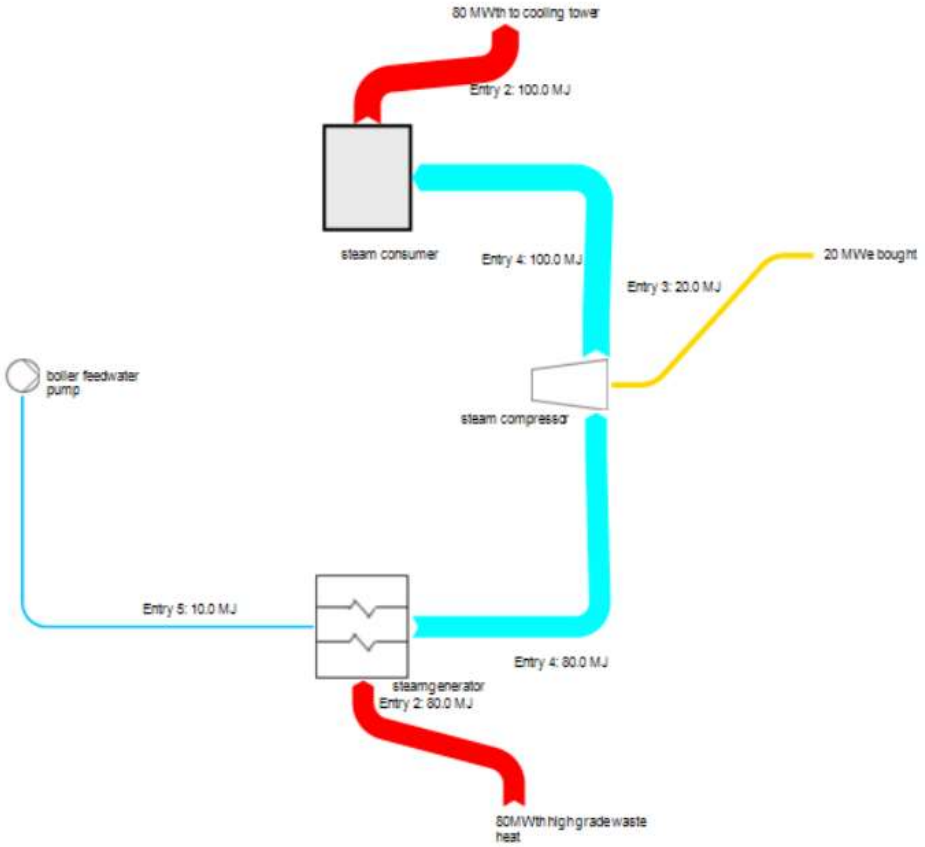
Turbine expansion and steam bottoming



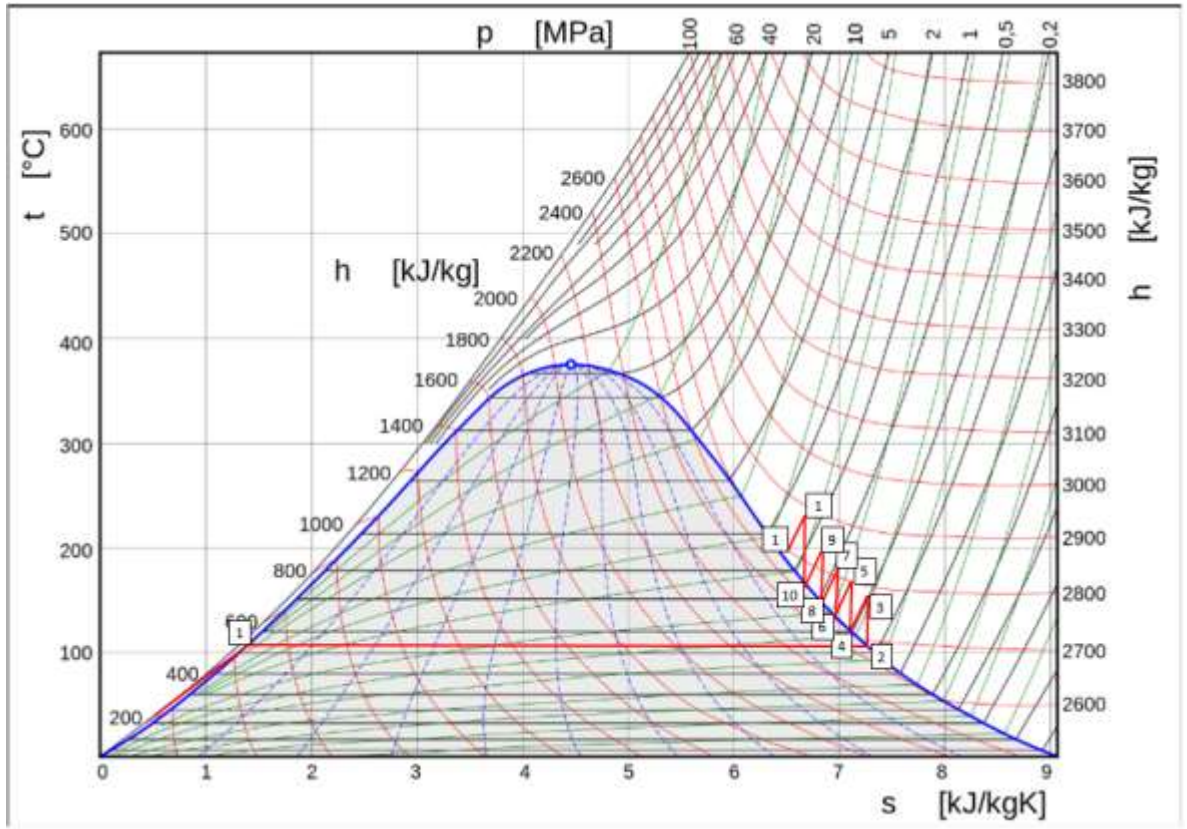
			steam work	latent waste heat	
point	H		dH 1-2	dH 2-3	
1	2800		300	2300	
2	2500				
3	200		efficciency	heat to work	
			0.13043478		

- Work is read by differences in enthalpies of the points 1 to 2
- Condensation heat is represented by 2-3.
- Efficiency from heat to work is about 13%. At power plants the start temperatures are much higher, therefore better efficiencies

Mechanical steam compression



MVR: Heat/work = COP



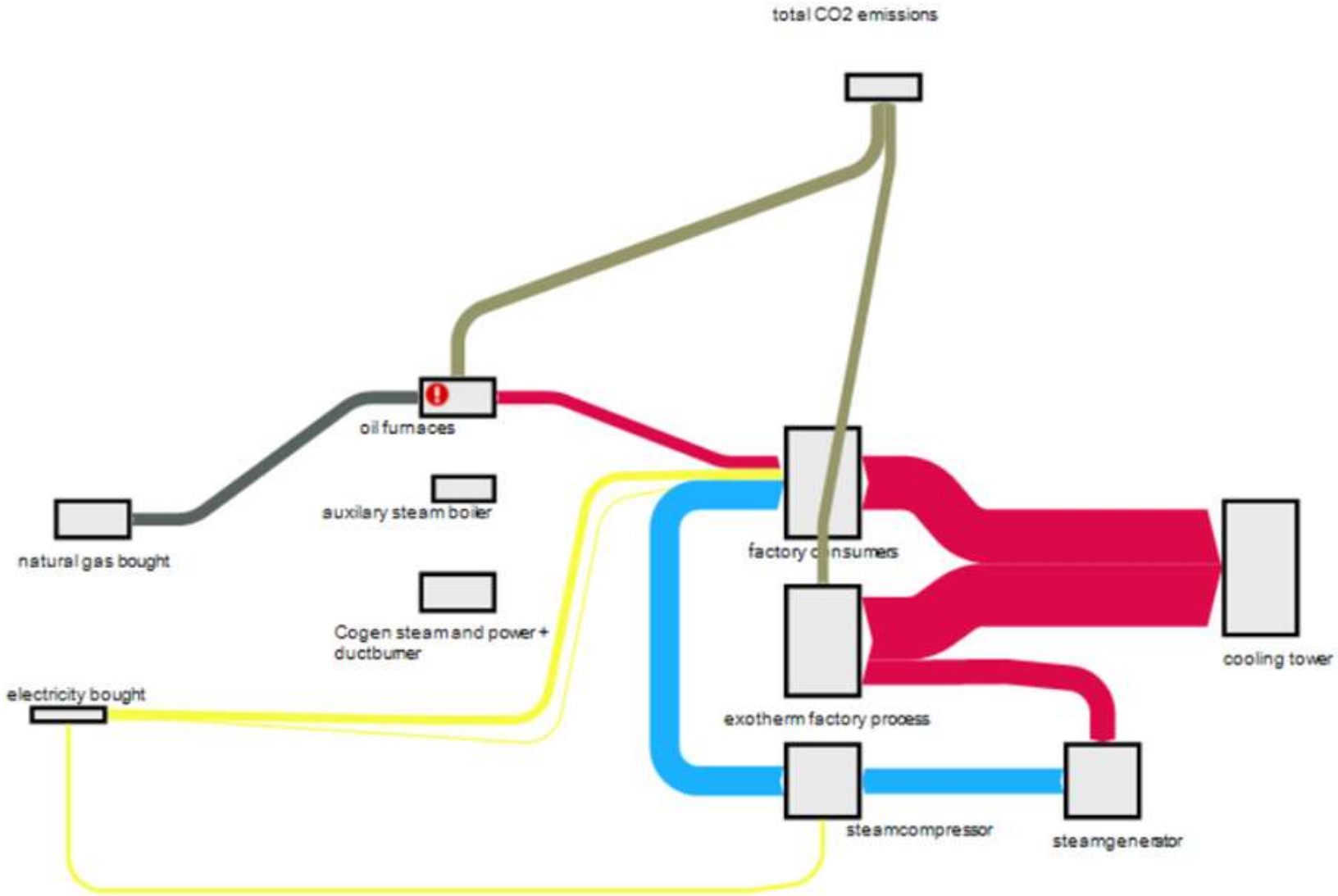
point	H
1	400
2	2650
3	2800
4	2700
5	2800
6	2700
7	2810
8	2710
9	2840
10	2750
11	2890
12	2800

heat by steamgenerator		
evap 1	dH 1-2	2250
work by compressor		
stage 1	dH 2-3	150.00
stage 2	dH 4-5	100
stage 3	dH 6-7	110
stage 4	dH 8-9	130
stage 5	dH 10-11	140
		630.00
heat by condensate injection		
stage 1	dH 3-4	150
stage 2	dH 5-6	100
stage 3	dH 7-8	100
stage 4	dH 9-10	90
stage 5	dH 11-12	90
		530

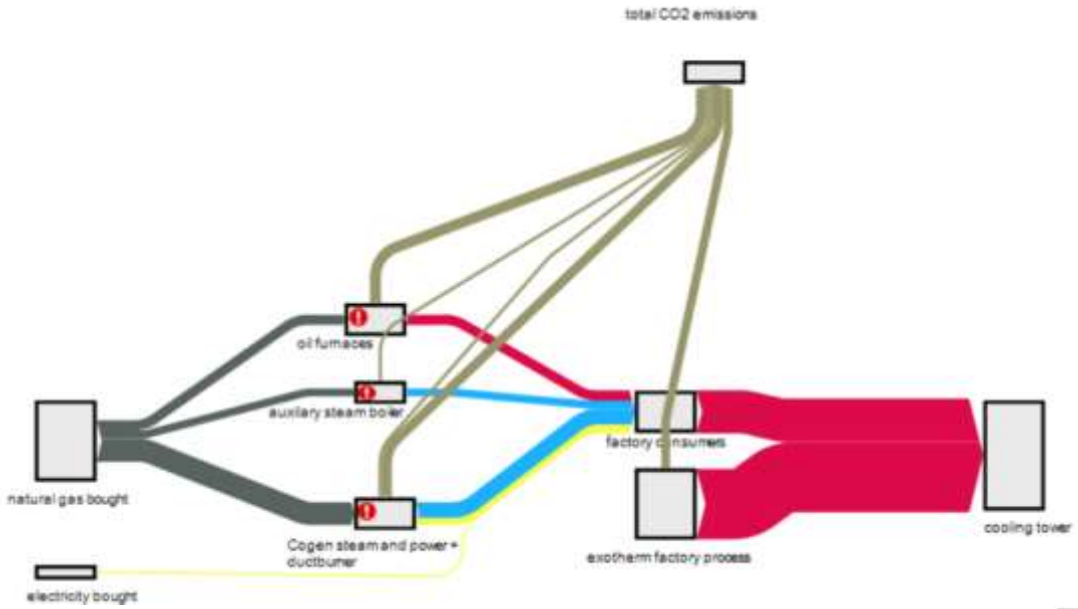
total heat delivered
2780
total work delivered
630.00
efficciency 1.5-15 bar (COP)
4.412698

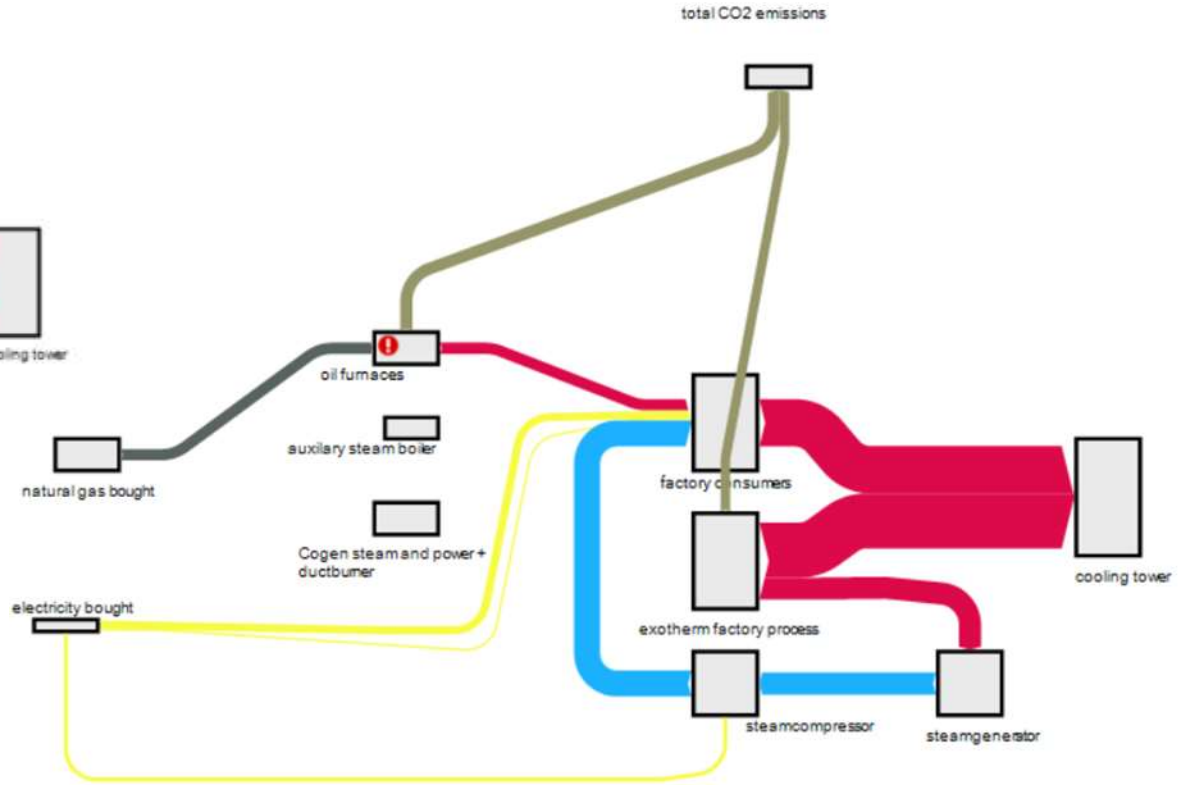
Heat of vaporization is 1-2. Vertical steps up are the compression work and diagonal down are the condensate injection cooling heat. COP for heatpump is heat / work

Implementation of MVR heatpump: 60 % reduction of natural gas CO2



Effect of heatpump before and after





Steam compressor (with permission from Atlas Copco)

Atlas Copco

Success factors

- Inlet temperature and pressure of waste heat. The higher the less work for compressor.
- Amount of waste heat. Better economies of scale above 50 ton steam per h.
- Desired end pressure of steam. Reduce the amount of steam to be delivered to the highest grid pressure. Rather distribute it over the different pressure levels in your steam grid to maximize overall COP.
- Interstage cooling by condensate injection creates extra steam from non-isentropic losses in compressor
- Open cycle has one less heatexchanger than closed heatpump cycle. Reduces Capex and better efficiency because of no transfer losses.