NTB
Interstate University of Applied Sciences of Technology Buchs
University of Applied Sciences of Eastern Switzerland

IES INSTITUT FÜR ENERGIESYSTEME

Vapour recompression for steam generation

new energy efficient concepts

1 Introduction

- Theoretical analysis of different steam generation concepts.
- Energy efficiency, CO2 emission, and operating cost for Switzerland and USA.
- Using free waste heat with 30-80° C.

2 Method overview

- The methods can be separated in two mechanisms: high-temperature evaporation & low-temperature evaporation.

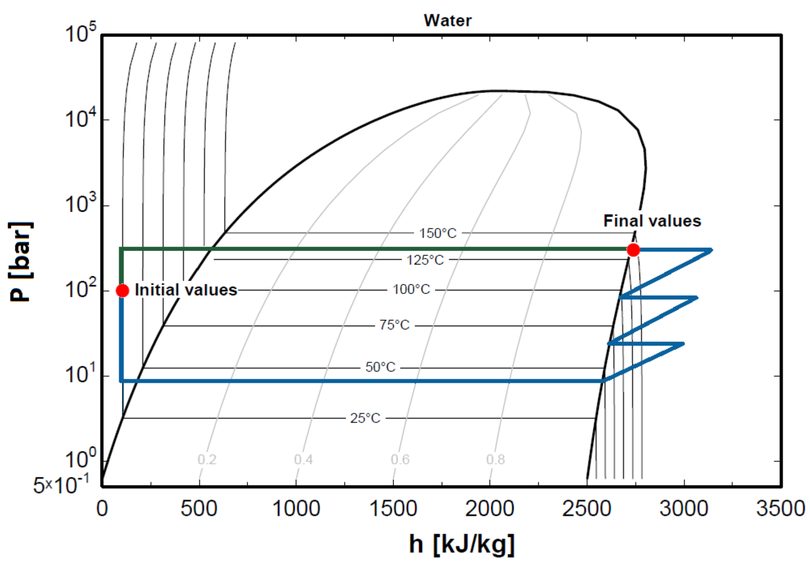
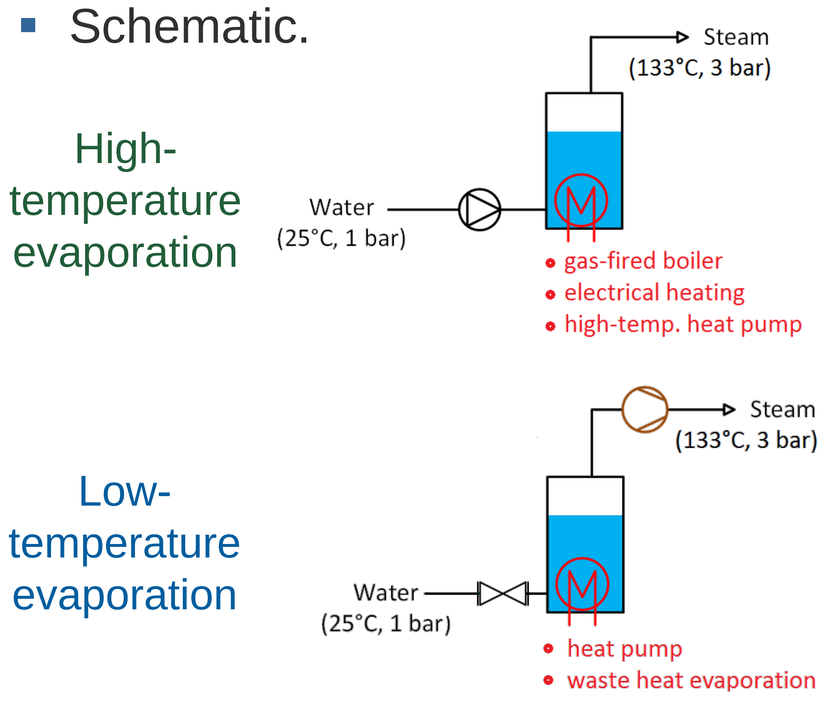


Figure: p-h diagram of water

- Schematic.



3 Results

- The amount of waste heat is assumed to be infinite and free.
- The compressors are assumed to have isentropic efficiencies of 75% and a maximal pressure ratio of 4.
- The high-temperature heat pump is simulated using isopentane (R601a).
- Heat sources for the heat pumps are fixed to 18° C if no waste heat.
- A pinch point of 5K is used in all heat exchangers.
- After the compression steps, the steam is cooled down using heat exchangers (HX) or water injection (WI).

4 Assumptions

Analysis of the different steam generation concepts.

- **Energy**
- **CO2**
- **Operating cost**

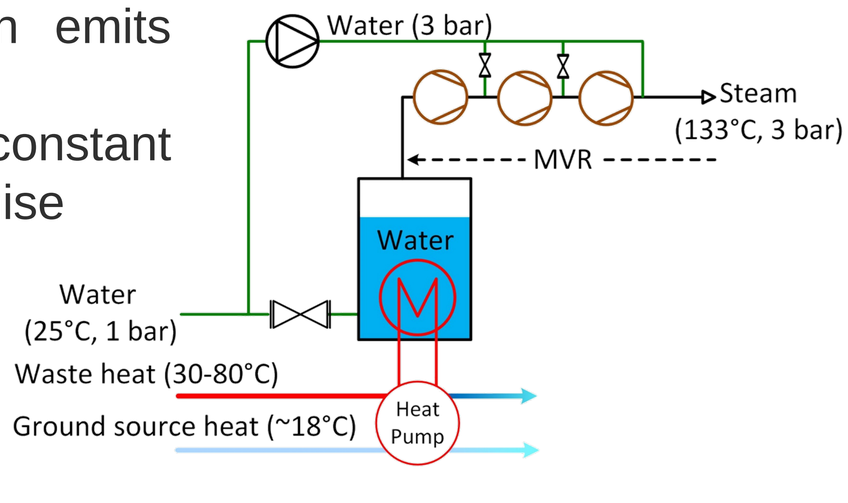
for Switzerland & US with & without waste heat.

Energy consumption, CO2 emission, and operating cost per kilo of steam

		without waste heat			with waste heat (55°C)		
	Steam generation method	kJ	CO_2 [g]	OC [¢]	kJ	CO_2 [g]	OC [¢]
direct heating	Natural gas-fired (US)	2758	139	1.8	2648	133	1.8
	Natural gas-fired (CH)			5.1			4.9
	Electrical heating (US)	2620	375	7.4	2516	360	7.1
	Electrical heating (CH)		27	12.0		26	11.5
	High temperature HP (US)	1849	265	5.2	1137	163	3.2
	High temp. HP (CH)		19	8.5		12	5.2
vapour compression	HP using HX cooling (US)	1180	169	3.3	836	120	2.4
	HP using HX cooling (CH)		12	5.4		9	3.8
	HP using WI cooling (US)	1106	158	3.1	755	108	2.1
	HP using WI cooling (CH)		11	5.1		8	3.5
	Waste heat evap. with HX (US)	-	-	-	772	111	2.2
	Waste heat evap. with HX (CH)			-		8	3.5
	Waste heat evap. with WI (US)	-	-	-	661	95	1.9
	Waste heat evap. with WI (CH)			-		7	3.0

5 Conclusions

- Geographical location has a huge impact on the operating cost.
- Waste heat evaporation emits less CO2
- If the waste heat is not constant through time, a compromise technology is a multi-temperature heat pump



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Project partners

SCCER EFFICIENCY OF INDUSTRIAL PROCESSES

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