Integration of ammonia cooling cycle in buildings heating system by the use of computer modeling

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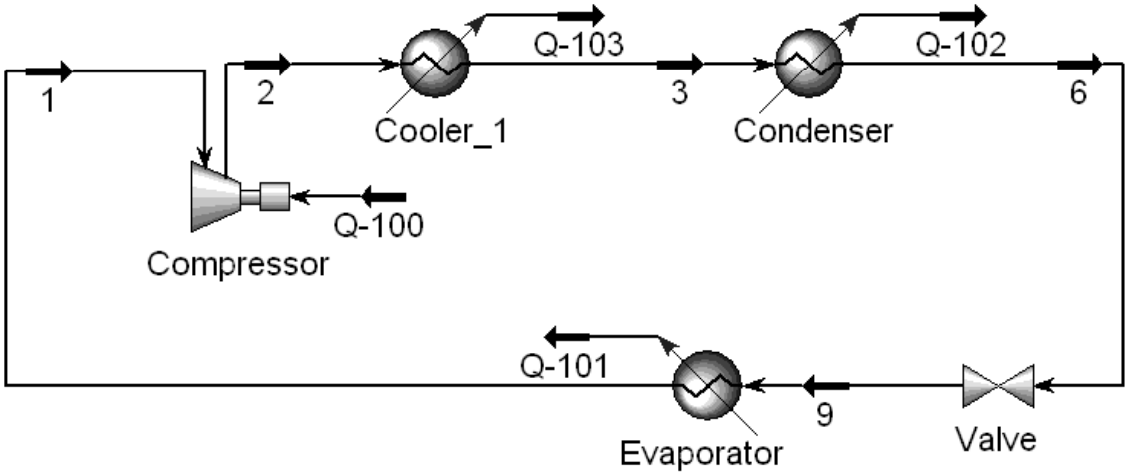
Introduction

- Ukrainian supermarkets use the ammonia refrigerating cycle
- Low potential heat is not used
- Potential customers of heat
- Process modelling by UniSim Design
- HEN Design by pinch-method
- 2 stage compression application

Process modelling by UniSim

Compressor		
Power	0,3210	kW
Feed Pressure	195,9	kPa
Product Pressure	1200	kPa
Product Temperature	155,2	C
Duty	1156	kJ/h



Evaporator		
Duty	-3733	kJ/h
Feed Temperature	5,318	C
Product Temperature	-19,00	C

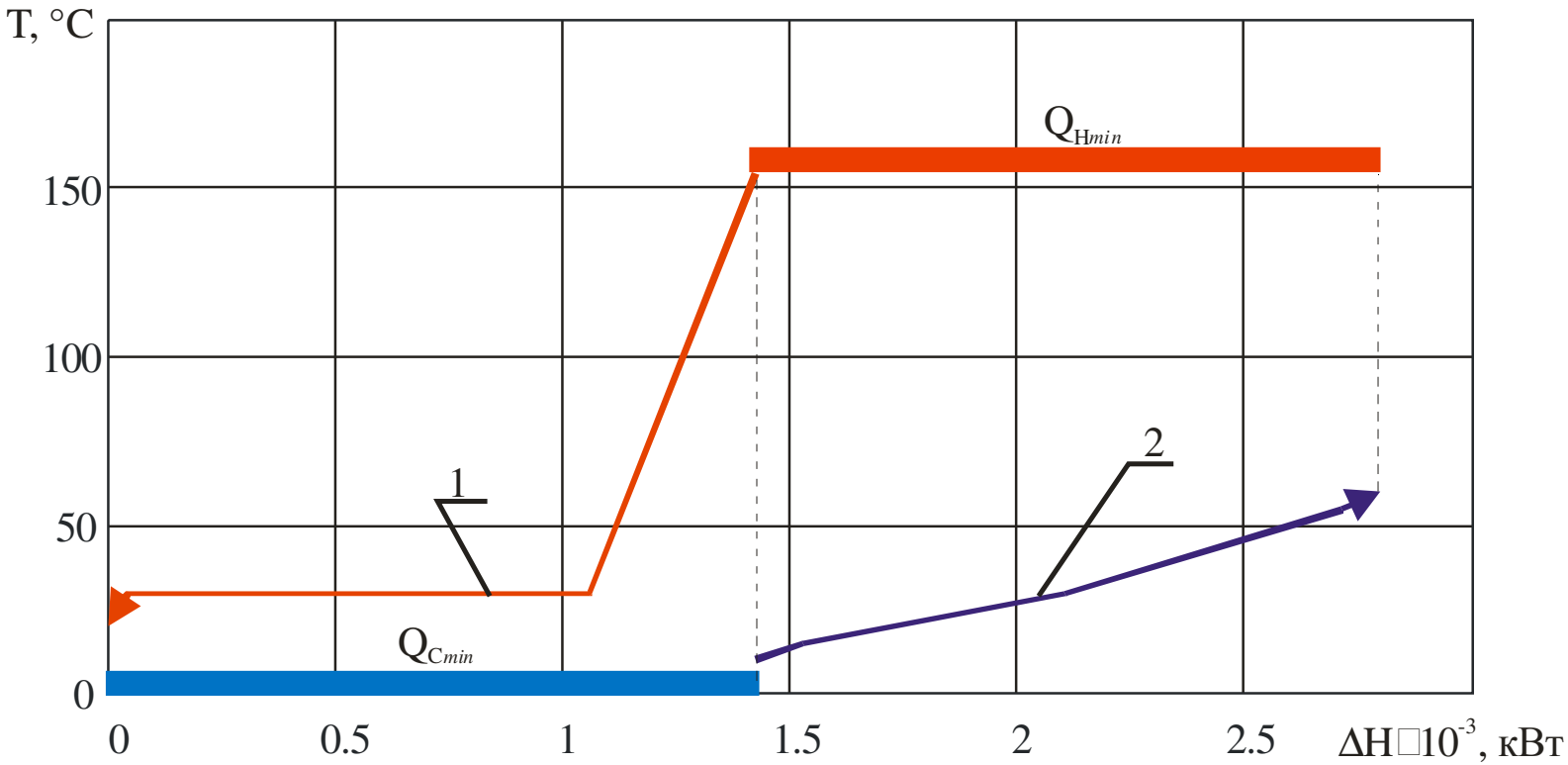
Condenser		
Duty	3956	kJ/h
Feed Temperature	31,00	C
Product Temperature	20,00	C

Stream data

№	Name	Type	TS, °C	TT, °C	G, t/h	C, kJ/(kg·°C)	r, kJ/kg	CP, kW/°C	DH, kW
1	Ammonia cooling	Hot	155	30	3.194	3.250		2.883	360.43
	Ammonia condensation	Hot	30	30	3.194		1146		1016.76
	Ammonia liquid cooling	Hot	30	20	3.194	4.750		4.214	42.14
2	Hot water supply	Cold	15	60	15.000	4.190		17.458	785.63
3	Air preheating	Cold	10	30	50.000	1.005		13.958	279.17
4	Air to fans	Cold	10	55	25.000	1.005		6.979	314.06

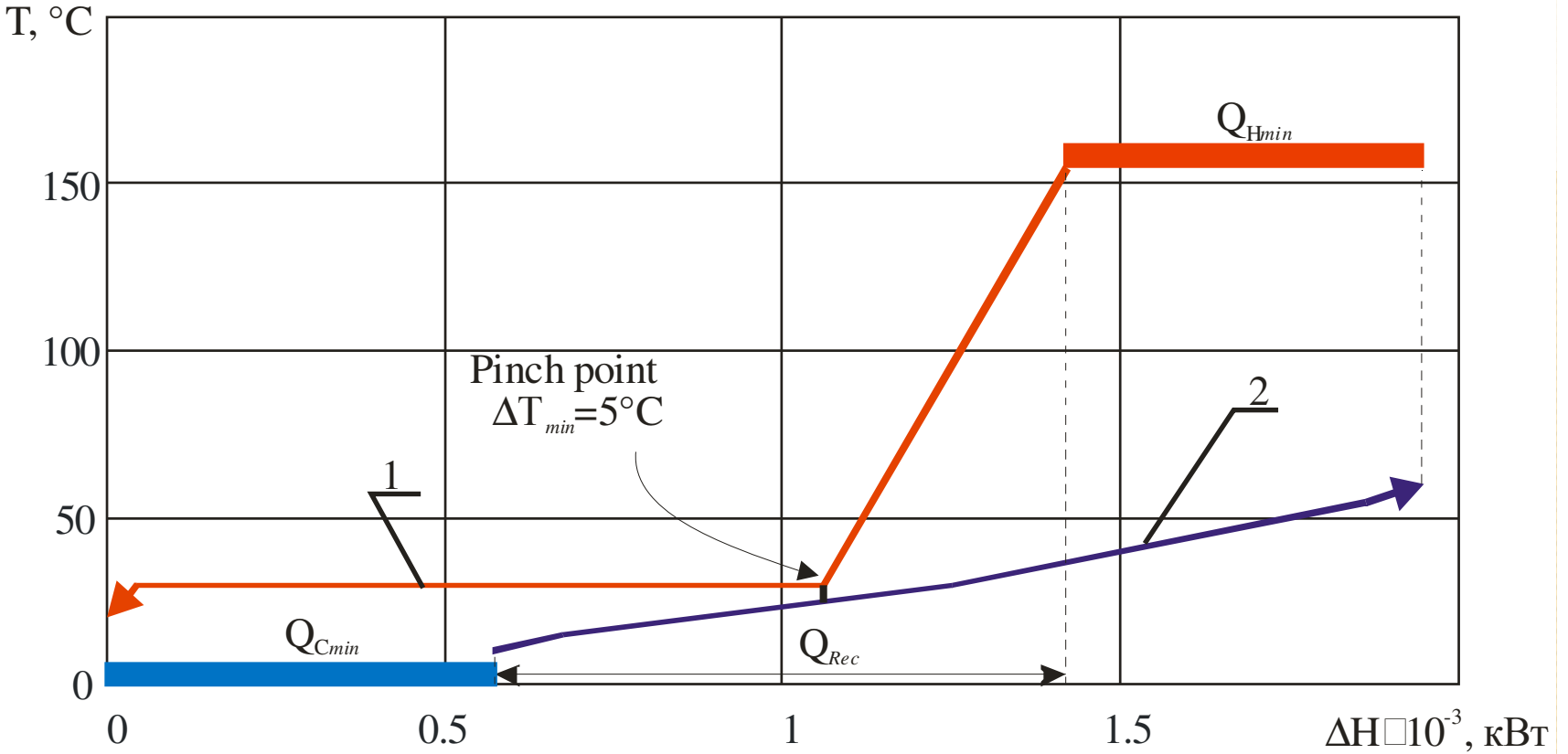
Composite curves of existing process

- Hot utilities – 1379 kW
- Cold utilities – 1419 kW

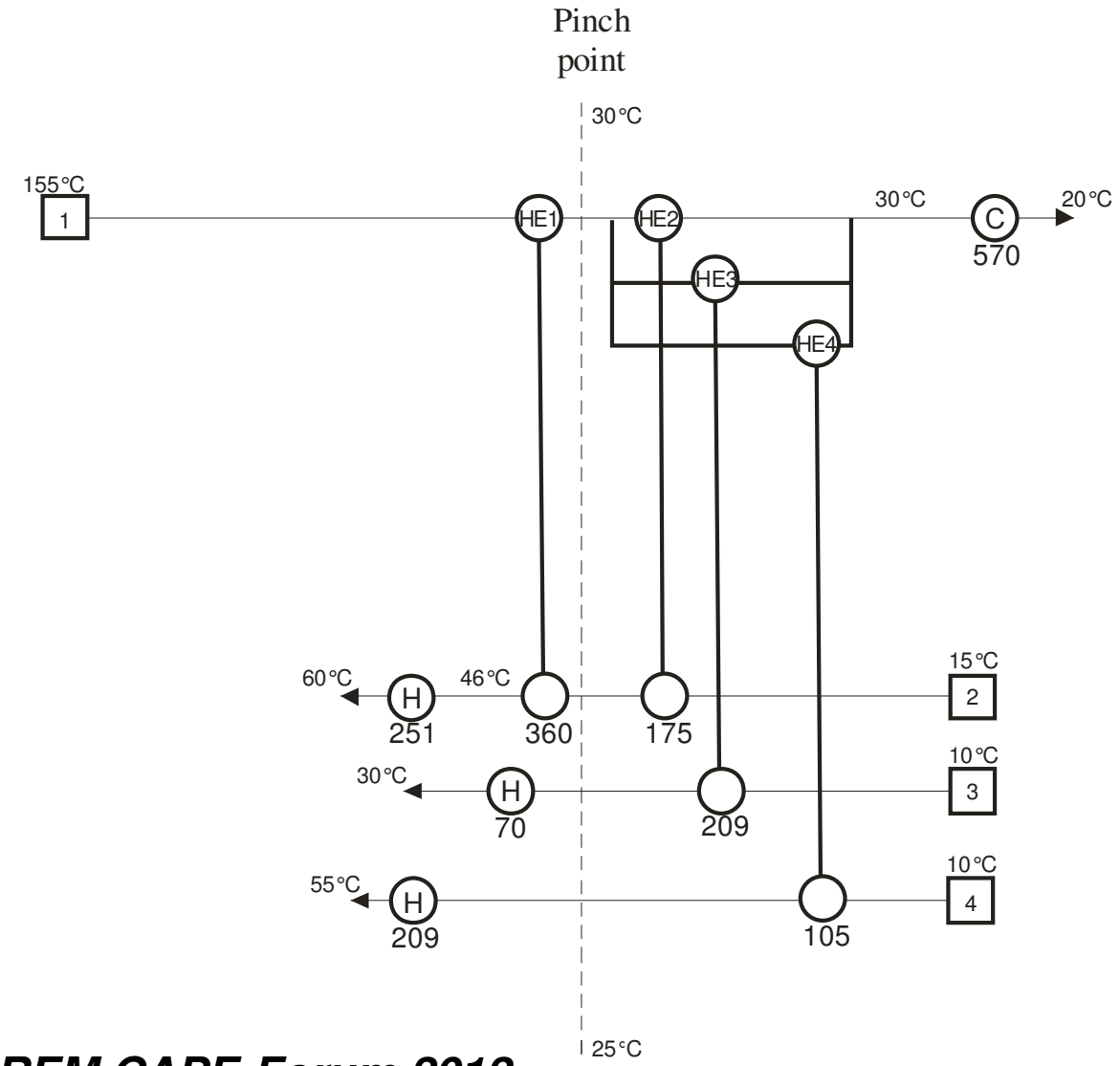


Composite curves of retrofit project

- Q_{Hmin} = 530 kW
- dT_{min} = 5°C
- Q_{Cmin} = 570 kW
- Q_{Rec} = 849 kW



HEN design



	CP, kW·s^{-1}	ΔH, kW
		1419
	17.46	786
	13.96	279
	6.98	314

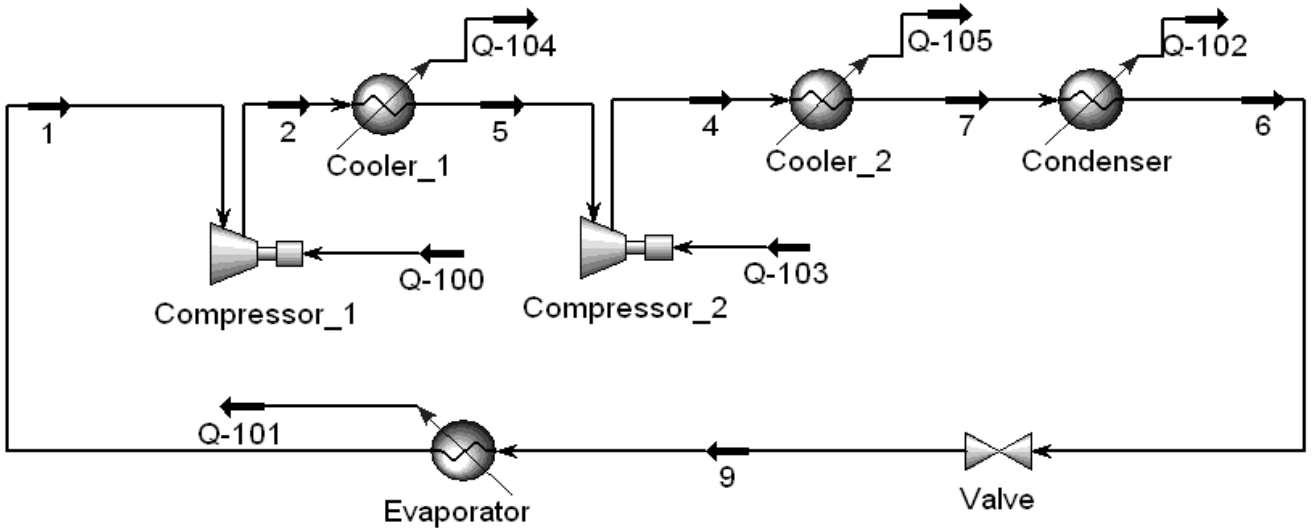
Summary

- Cooling duty reduction – 849 kW
- Heating duty reduction – 849 kW
- dT_{min} = 5°C
- New HEN – 4 plate heat exchangers
- Heat-exchange area – 225 m^2
- Payback period – 5 months

Process changes

Compressor_1		
Power	0,3210	kW
Feed Pressure	195,9	kPa
Product Pressure	1200	kPa
Product Temperature	155,2	C
Duty	1156	kJ/h

Compressor_2		
Power	0,1347	kW
Feed Pressure	1190	kPa
Product Pressure	2604	kPa
Product Temperature	111,4	C
Duty	485,0	kJ/h



Evaporator		
Duty	-3731	kJ/h
Feed Temperature	20,06	C
Product Temperature	-19,00	C

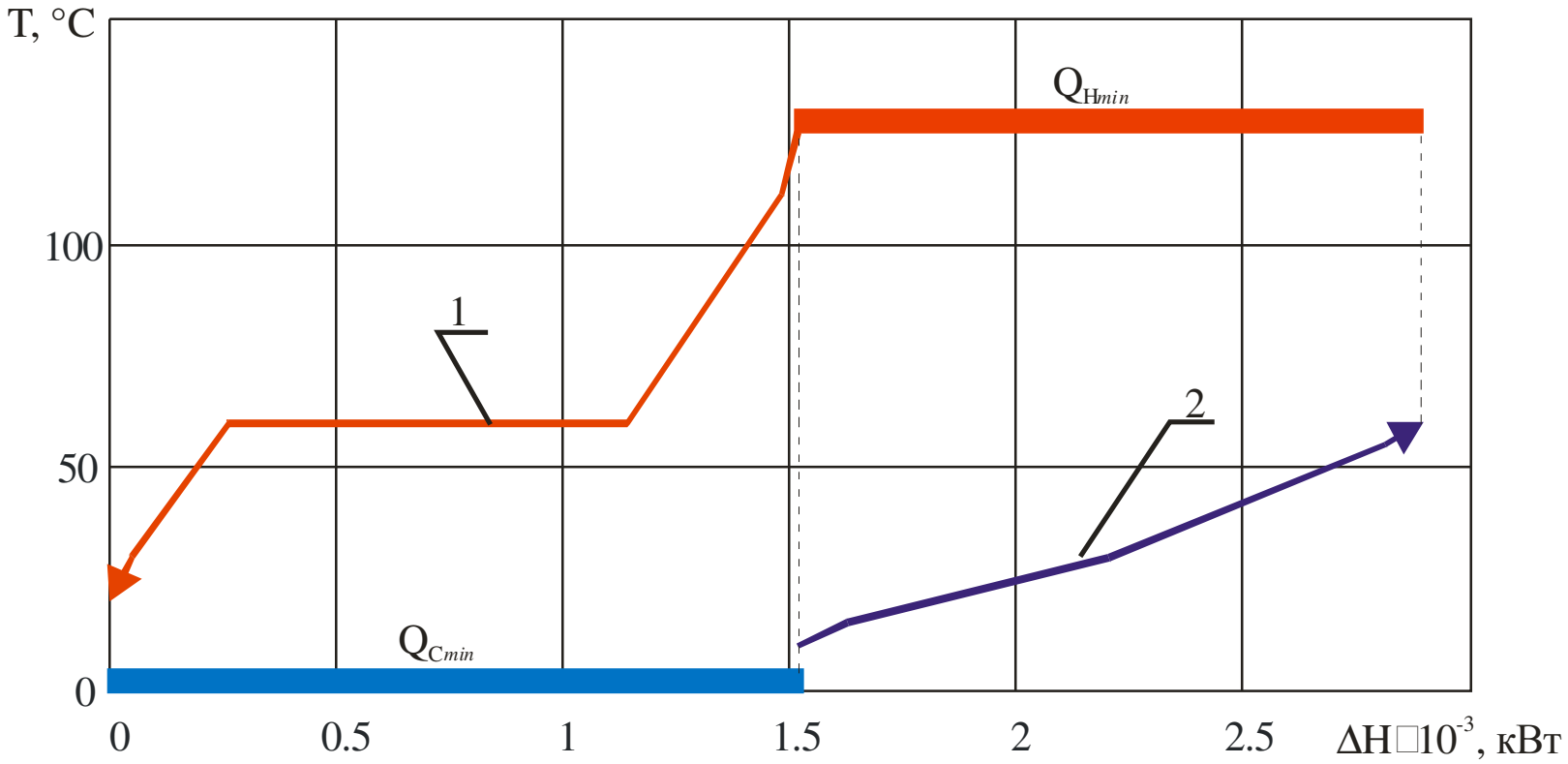
Condenser		
Duty	585,5	kJ/h
Feed Temperature	55,00	C
Product Temperature	20,00	C

Stream data

№	Name	Type	TS, °C	TT, °C	G, t/h	C, kJ/(kg·°C)	r, kJ/kg	CP, kW/°C	DH, kW
1	Ammonia cooling 1 stage	Hot	125	30	3.194	3.250		2.883	273.93
2	Ammonia cooling 2 stage	Hot	111	60	3.194	4.275		3.793	193.44
	Ammonia condensation	Hot	60	60	3.194		986.2		874.98
	Ammonia liquid cooling	Hot	60	20	3.194	4.935		4.378	175.14
3	Hot water supply	Cold	15	60	15.000	4.190		17.458	785.63
4	Air preheating	Cold	10	30	50.000	1.005		13.958	279.17
5	Air to fans	Cold	10	55	25.000	1.005		6.979	314.06

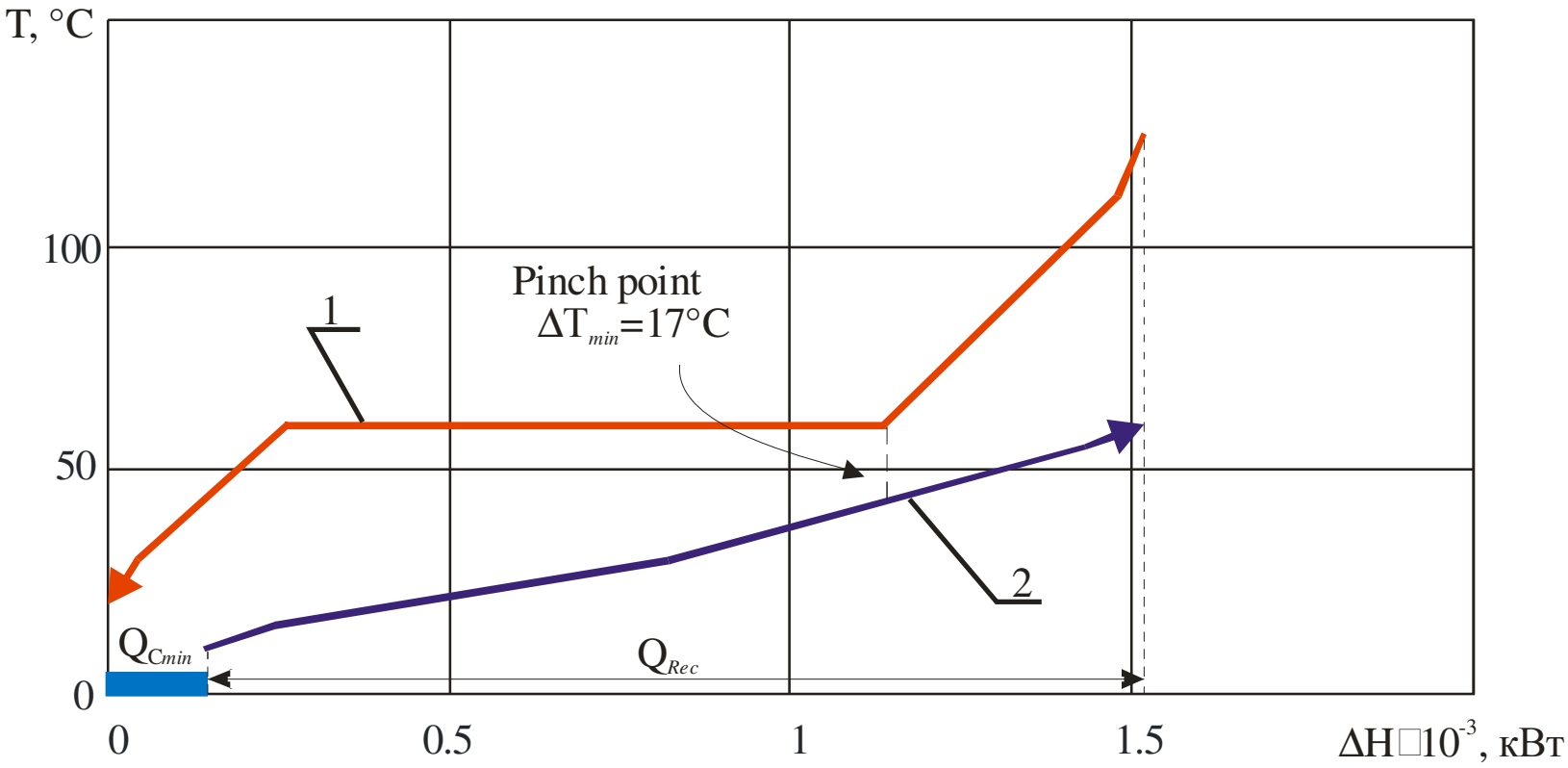
Composite curves of existing process

- Hot utilities – 1517 kW
- Cold utilities – 1379 kW

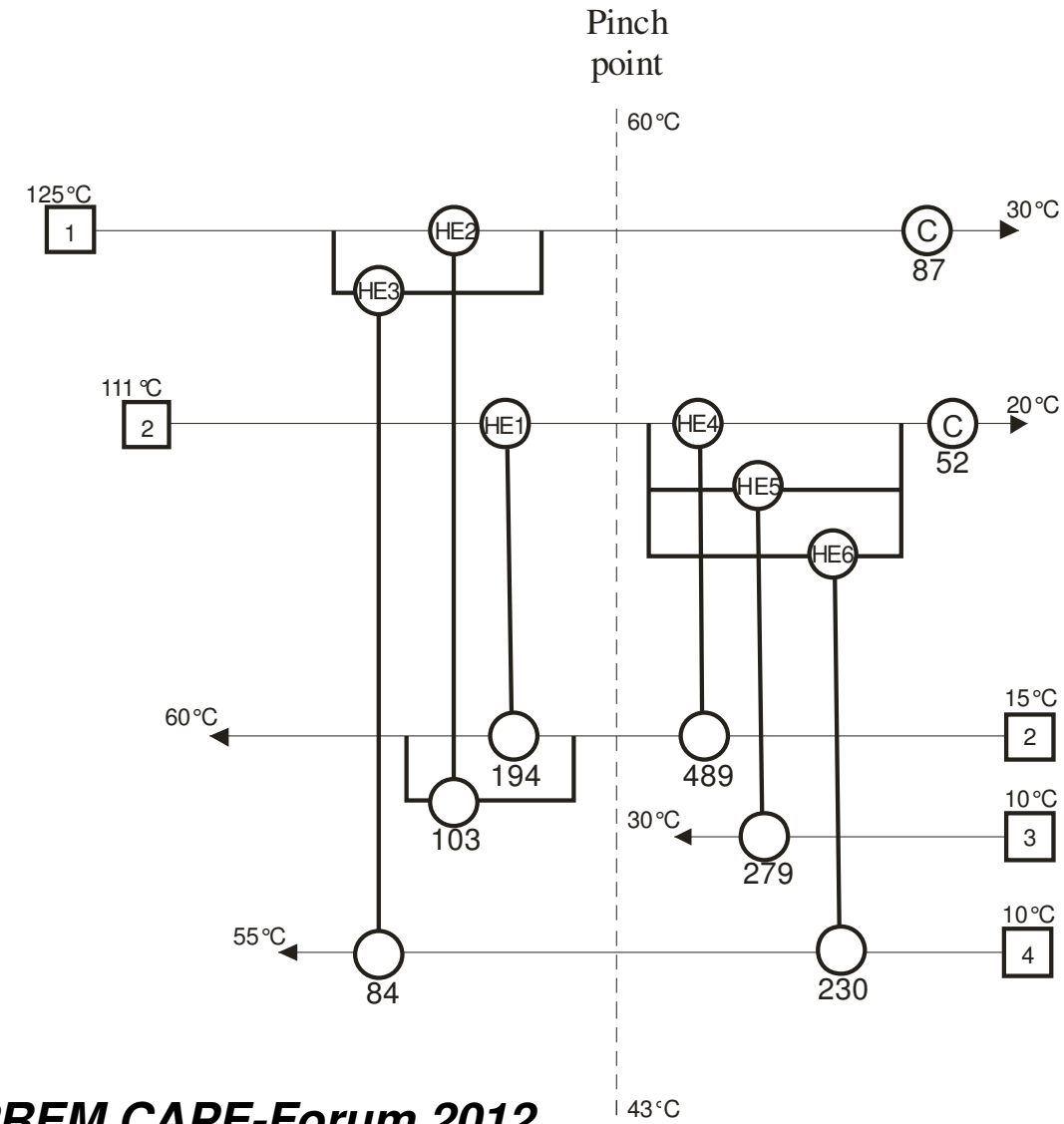


Composite curves for retrofit project

- Q_{Hmin} = 0 kW
- Q_{Cmin} = 139 kW
- dT_{min} (threshold)= 17°C
- Q_{Rec} = 1379 kW



HEN Design



	CP, kW□s^{-1}	ΔH, kW
	2.88	274
		1244
	17.46	786
	13.96	279
	6.98	314

Summary

- Cooling duty reduction – 1379 kW
- Heating duty reduction – 1379 kW
- Threshold problem
- dT_{min} = 17°C
- New HEN – 6 plate heat exchangers
- Heat-exchange area – 377 m^2
- Additional compressor – 135 kW
- Payback period – 7 months

Conclusion

I stage compression

- Recuperation – 849 kW
- dT_{min} = 5°C
- New HEN – 4 PHEs
- Heat-exchange area – 225 m^2
- Payback period – 5 months

Software used:

- Unisim Design (Honeywell)
- CAS (Alfa Laval)
- Pinch02 (NTU "KhPI")

2 stage compression

- Recuperation – 1379 kW
- dT_{min} = 17°C
- New HEN – 6 PHEs
- Heat-exchange area – 377 m^2
- 1 compressor – 135 kW
- Payback period – 7 months

THANK YOU