



kongres

**47th HVAC&R CONGRES AND EXHIBITION :
IMPROVING ENERGY EFFICIENCY IN CLIMATE AND OZONE FRIENDLY LATEST
REFRIGERATION TECHNOLOGIES.
NEW TECHNOLOGY CASE STUDIES USING 'NATURAL 5' REFRIGERANTS**

30.XI – 2. XII 2016 . Beograd, Srbija



MAYEKAWA Europe nv/sa DOC.2016-882 R.1

Presented by Jan Boone, MAYEKAWA

"Natural Five" Refrigerants and Product Solutions

Refrigerant (Natural Five)	NH ₃ R-717	CO ₂ R-744	HC Hydrocarbon	H ₂ O R-718	Air R-728
90°C	Utility hot water	Utility hot water		Heat recovery	
60°C			Utility hot water Heating HVAC		
10°C	Chilled water Ice making	Chilled water Ice making		Chiller	
-15°C	Cold storage, Freezer, Fish boat				
-25°C	Specific Refrigeration needs				
-40°C	Freezer, Freeze-dry, Super Low temp storage				
-50°C			Cryogenics		
-60°C					
-100°C					Cryogenics
Notes	• Conventional system • National Projects	• Eco-Cute	• Nat'l Proj. • Butane + Propane	• Nat'l Proj. • Adsorption • Heat recovery	• Nat'l Proj. • Air-cycle

FIELD CASE



NATURAL REFRIGERANTS

*+3 ° NH3 district cooling system
combined with
+70 ° C district heating NH3 heat pump*

in District Energy Industry

presentation by : Jan Boone

INTRODUCTION

PLANT	NYDALEN	14,5mW heating station
NEED	13.500kW water +7°C	District cooling of technical rooms and Equipment, computers and banks
	2.400kW water at +65°C	District heating for offices and sanitary water
CHOICE	NH3	N5 NH3 : refrigeration + heat pump
	68°C hot water	reduce boiler gas consumption NH3 heat pump (ODP & GWP=0) Tc=70°C (32,6 barg) Use 'waste heat' <>condensor load
TIME FRAME	2010 2014	Install 1st compressor for 1700 kW chilling Install 2nd part for 11800 kW chilling and 2400 kW heating
BY	CONTRACTOR	THERMA in Norway

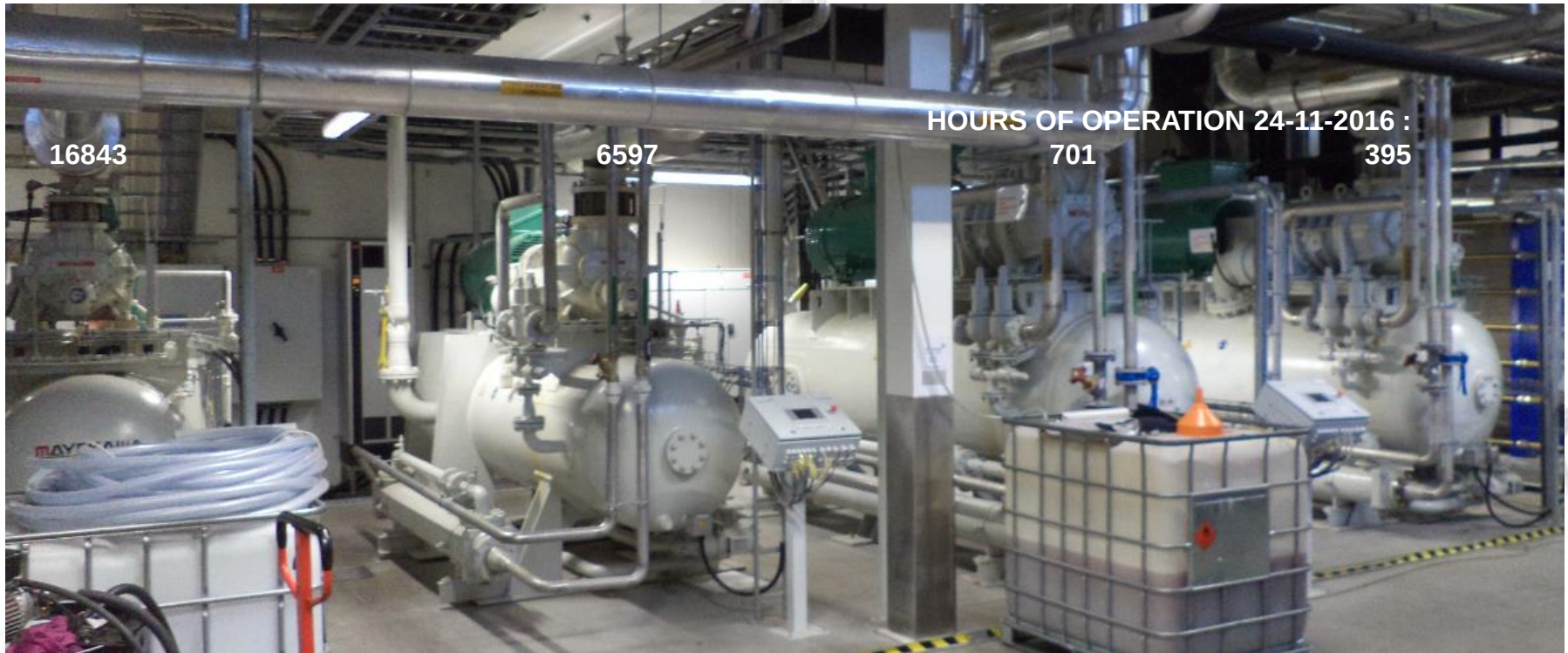
INSTALLED EQUIPMENT COOLING

COMPRESSORS	4 PCS TWIN SCREW TYPE 26 bar
MOTORS	730kW, 450kW, 350kW (VFD)
EVAPORATORS	PHE 2 PCS EACH 5.750 kW 4°C, water 13/7°C
CONDENSORS	PHE 2 PCS EACH 7500 kW 33°C, water 24,5/31°C
HEAT SOURCE FLASH TANK	OPEN FLASH TANK 2500 kW 33°C
OIL COOLING	TO=50°C, HEAT RECOVERY 40/45°C
COOLING LOAD	700 TO 13500 kW

INSTALLED COMPRESSORS - CHILLING

NR	MODEL	SO	SPEED		TE	TC	RT	BKW	QC	OHR	COP _c
			min.	max.							
			rpm	rpm	°C	°C	kW	kW	kW	kW	
1	N320VMD	60982-1		2950	3	33	4543	678	5221	172	6,7
2	N320VMD	60982-2		2950	3	33	4543	678	5221	172	6,7
3	N250VLD	60982-3		2950	3	33	2717	401	3118	94	6,8
4	N200VLD	48689	1500	3550	3	33	1690	252	1942	87	6,7
	total						13493	2009	15502	525	6,7

PLANT VIEW



NH3 DISTRICT CHILLING SYSTEM

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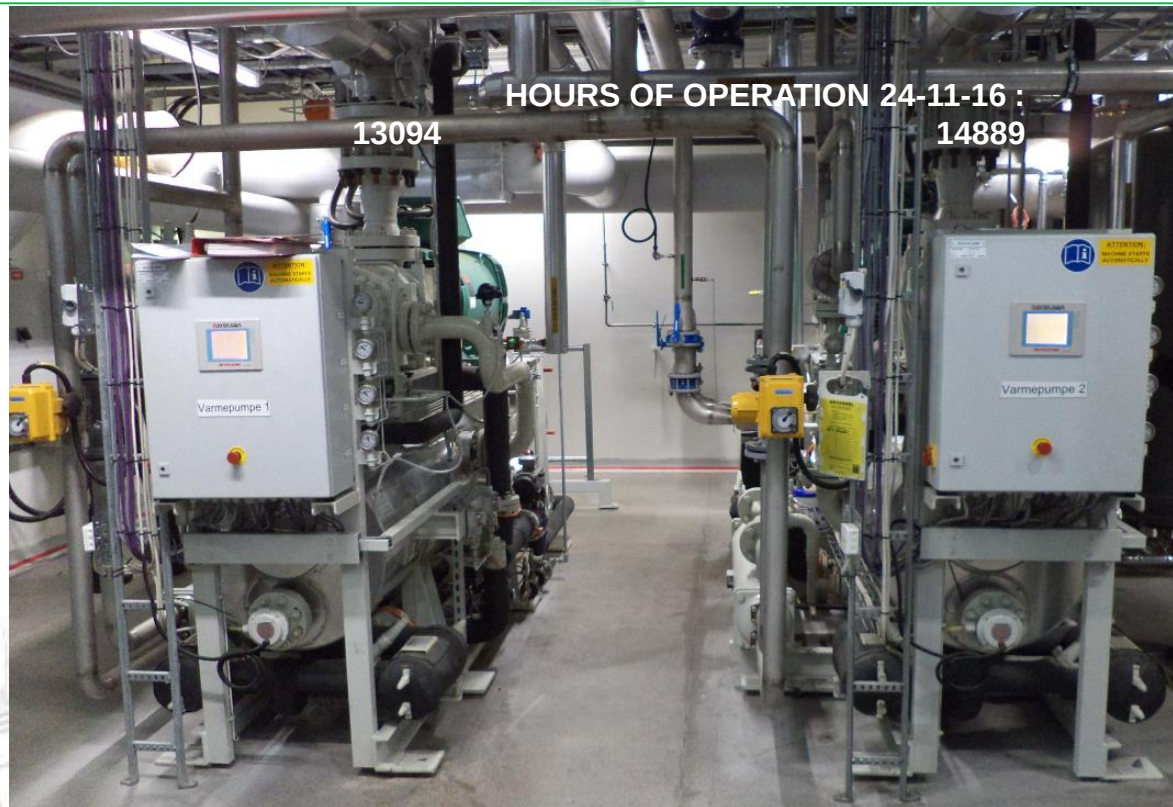
INSTALLED EQUIPMENT HEATING

COMPRESSORS	2PCS TWIN SCREW TYPE 50bar
MOTORS	250 kW (VFD)
CONDENSORS	PHE 2000 kW 70°C, water 40/68°C
OIL COOLING	TO=60°C, HEAT RECOVERY 40/55°C
HEATING LOAD	MINIMUM 700 kW TO 2400 kW

INSTALLED COMPRESSORS - HEATING

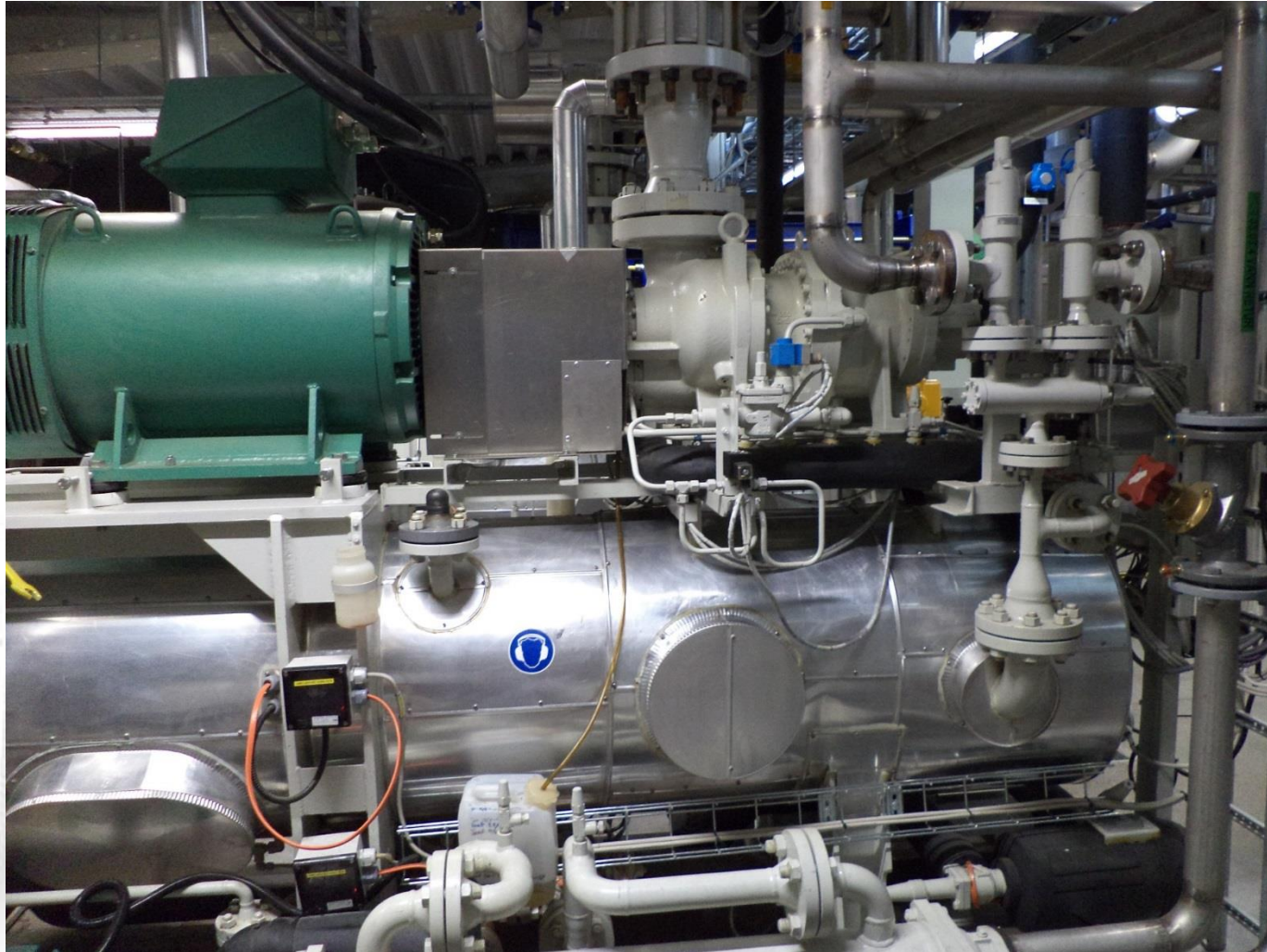
NR	MODEL	SO	SPEED		TE	TC	RT	BKW	QC	OHR
			min.	max.						
			rpm	rpm	°C	°C	kW	kW	kW	kW
	SUMMER	50°C hot water								
1	N160GHS	60982-3	1800	3300	33	53	1053	120	1173	30
2	N160GHS	60982-3	1800	3300	33	53	1053	120	1173	30
							2106	240	2346	60
	WINTER	65°C hot water								
1	N160GHS	60982-3	1800	3300	33	70	915	214	1129	117
2	N160GHS	60982-3	1800	3300	33	70	915	214	1129	117
							1830	428	2258	234

PLANT VIEW



NH3 DISTRICT HEATING SYSTEM

HOT WATER NH3 COMPRESSOR MODEL N160GHS 50 bar



PLANT LOAD

SEASON	CHILLING	HEATING	HEAT SOURCE
WINTER	Technical rooms (computer servers etc.) 700 kW	1000 kW	Chilling heat rejection
SPRING	Technical rooms 700 kW	1000 kW	Chilling heat rejection
SUMMER	District cooling needed 1500 to 8500 kW	Minimum heating 500 kW	Chilling heat rejection
AUTOMN	Technical rooms 700 kW	1000 to 2300 kW for district heating	Chilling heat rejection + river water chilling (t°water > 4°C)

winter heat source : district cooling

	WINTER				
	December till March				
	RT	BKW	QC	rpm	COP
	kW	kW	kW	rpm	
CHILLING					
N320VMD				0	
N320VMD				0	
N250VLD				0	
N200VLD	700	104	804	1500	
OUTPUT	700	104			6,73
HEATING					
N160GHS	804	188	992	2900	
N160GHS				0	
OUTPUT	804	188	992		5,28
extra					
	usable chilling heat rejection				
	fully used for heat pump				

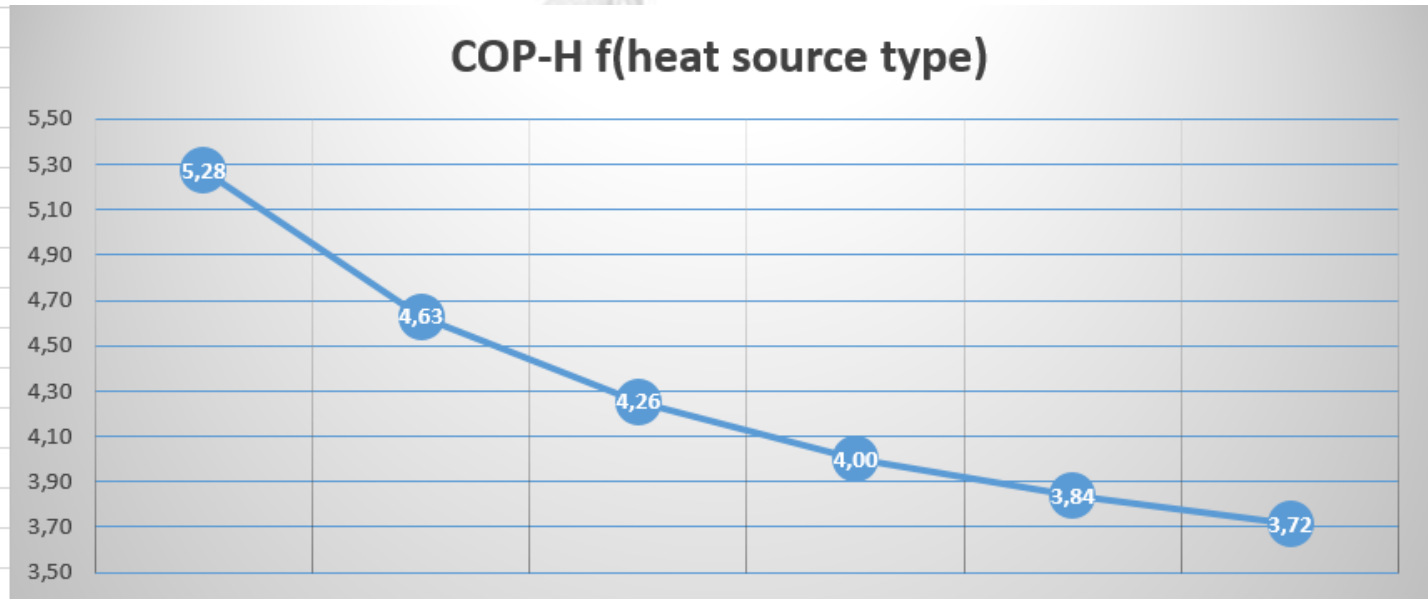


summer heat source : district cooling

	SUMMER			
	June till August			
	RT	BKW	QC	rpm
CHILLING	1500 to 8500			
N320VMD	4543	678	5221	2950
N320VMD				0
N250VLD	2717	401	3118	2950
N200VLD				0
OUTPUT	7260	1079	8339	
HEATING				
N160GHS	415	97	512	1500
N160GHS				0
OUTPUT	415	97	512	
extra				
minimum heat load regime !				
only limited part of chilling				
heat rejection (415kW) used				
for heat pump for limited regime				



mid-season heat source : district + river water cooling



65°C water OUTPUT(kW)	992	1238	1481	1732	1980	2258
HEAT SOURCE(kW)						
district cooling	700	700	700	700	700	700
river water cooling	0	169	332	498	665	845
SHAFT POWER INPUT						
district cooling	104	104	104	104	104	104
heat pump	188	234	280	328	376	428
river water cooling	0	34	69	106	141	179
total	188	268	349	434	517	607

NH3 HEAT PUMP OPERATION

		JAN	FEB	MAR	APR	MAY
CHILLING	kW	700	700	700	700	700
HEATING	kW	992	992	992	992	992
BKW heat pumps	kW	188	188	188	188	188
BKW river source	kW	0	0	0	0	0
BKW-total	kW	188	188	188	188	188
COPh		5,28	5,28	5,28	5,28	5,28
heat pumps						
hours operation		744	672	744	720	744
heat energy/month	kWh	738048	666624	738048	714240	738048
energy input/month	kWh	174840	157920	174840	169200	174840
note		700 kW chilling heat rejection fully used for heat pump			limited 700kW chill. heat rejection->hp no river source	

NH3 HEAT PUMP OPERATION

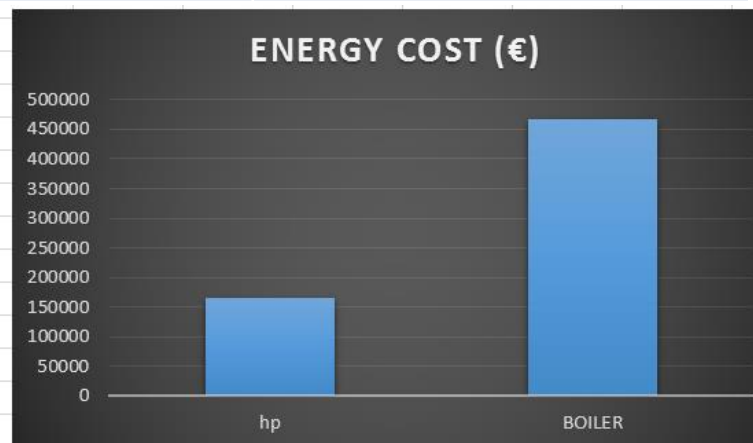
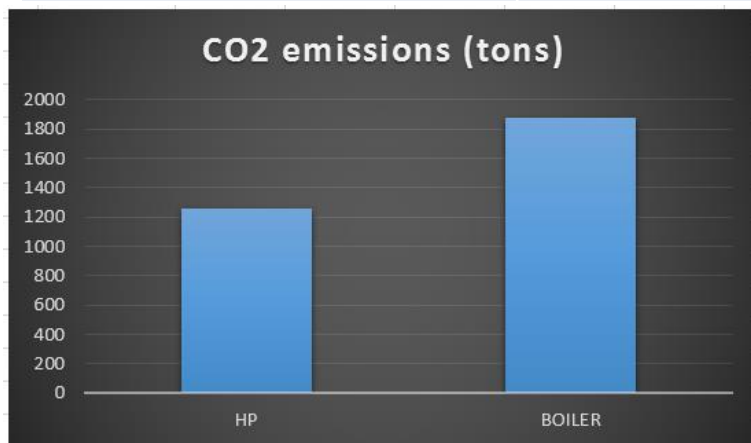
		o			o			o	
		JUN	JUL	AUG	SEPT	OCT	NOV	DEC	
CHILLING	kW	1500 to 8500				700	700	700	
HEATING	kW	500	500	500	1129	2258	2258	992	
BKW heat pumps	kW	96	96	96	214	428	428	188	
BKW river source	kW	0	0	0	0	179	179	0	
BKW-total	kW	96	96	96	214	607	607	188	
COPh		5,21	5,21	5,21	5,28	3,72	3,72	5,28	
heat pumps									
hours operation		720	744	744	720	744	720	744	8760
heat energy/month	kWh	360000	372000	372000	812880	1679952	1625760	738048	9555648
energy input/month	kWh	86400	89280	89280	192600	564510	546300	174840	2594850
									3,68
note		minimum heat pump operation approx. 500 kW			heating increase to full capacity using chiller heat as source + river water source				

OPERATION SAVINGS

NATURAL 5 REFRIGERANTS

FOR DISTRICT COOLING- & HEATING

	HEAT PUMP	GAS BOILER
Performance (COP)	4,60 (-20%→3,68)	0,9
Hot water (yr)	9.555 mW	10.616 mW
Energy consumption primary (8760 hrs/yr)	2.596 mWh	10.616 mWh
Energy prices	€ 66/mWh	€ 44 /mWh
Energy costs	€ 171.366,-	€ 467.104,-
CO2 emissions	1.298 tons	1.879 tons



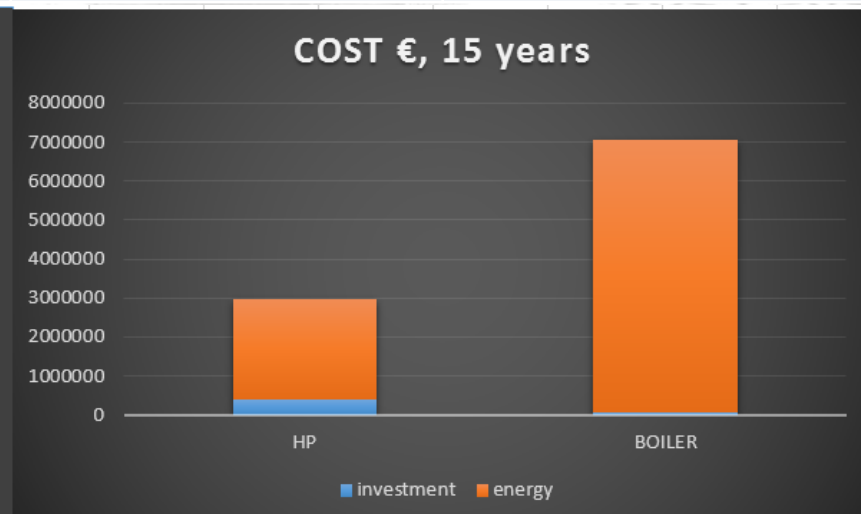
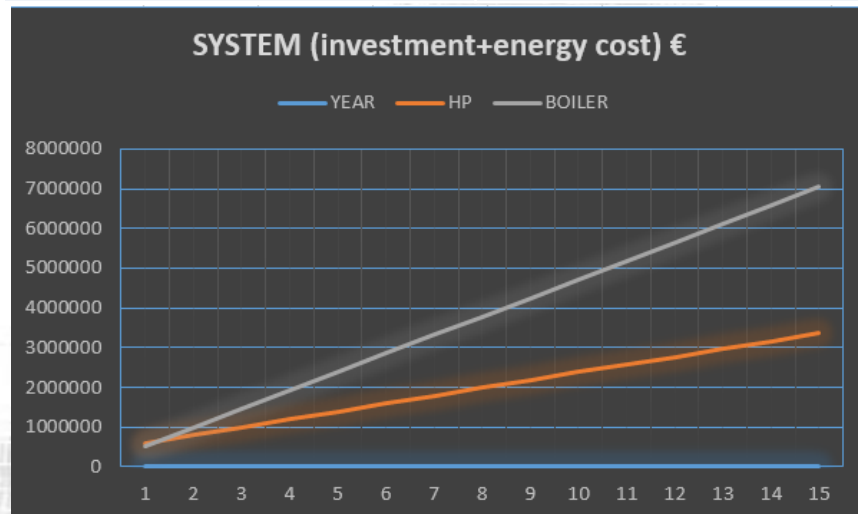
OPERATION SAVINGS

NATURAL 5 REFRIGERANTS

FOR DISTRICT COOLING- & HEATING

HEAT PUMP

	HEAT PUMP	BOILER	SAVINGS
Energy costs/yr	171.366 €	467.104 €	295.738 € (63%)
CO2 emissions/yr	1.298 ton	1.879 ton	581 ton (30%)
investment	400.000 €	50.000 €	-350.000 €
Energycost 15yrs	2.570.490 €	7.006.560 €	4.436,070 €
Maintenance cost 15y	400.000 €		-400.000 €
Total cost 15y	3.370.490 €	7.056.560 €	3.686.070 €



R.O.(Investment + energy cost) < 2 years

TRAINING

Product : organized by Mayekawa to the contractors

System : organized to Contractors, with Mayekawa-support, to the users.



INSTALLATION + COMMISIONING + OPERATION

Installation	Contractor + Mycom support
Commisioning (monitoring)	Contractor + Mycom support
Finetuning regulation/operation (monitoring)	Stability & long lifetime Machine logbook
Reference registration (monitoring)	Future evaluations (site)
Event registration (monitoring)	For every action (site &/ remote)
Operation registration (monitoring)	Regular basis (site &/ remote)

SERVICE & MAINTENANCE

Daily checks	Qualified personnel (operators, Contractor service persons)
Routine checks	idem
Main service (overhauls)	V type : every 3 years GHS type : every 3 years
Lubrication oil	Regular check Preventive analysis Preventive particle filtration
Registration	For every service & maintenance activity

Special thank-word :

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KULDE VARME ENERGI

NORWAY





NATURAL 5 REFRIGERANTS

FOR DISTRICT COOLING- & HEATING

MARKET AVAILABILITY

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Thank you very much !



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