NATURAL REFRIGERANTS

NH3 high pressure heat pump hot water production for district heating

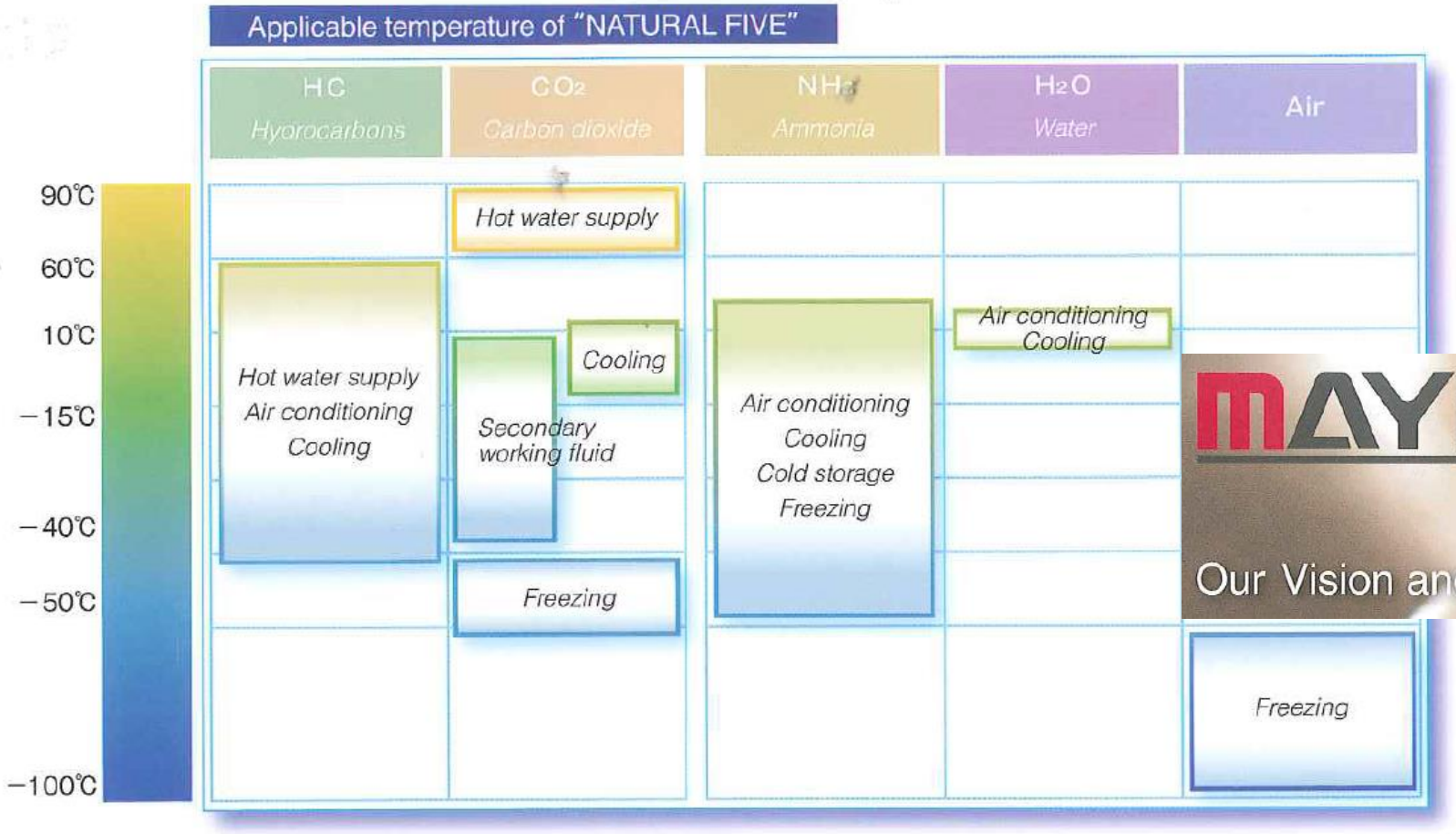
Presented by Jan Boone, MAYEKAWA

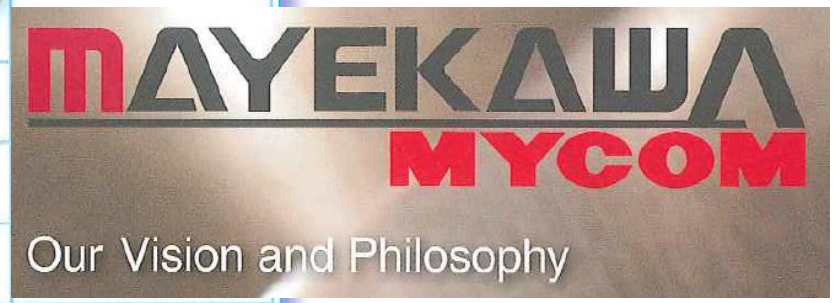
"Natural Five" Refrigerants and Product Solutions

Refrigerant (Natural Five)	NH_3 R-717	CO_2 R-744	HC Hydrocarbon	H_2O R-718	Air R-728
90℃ / 60℃ / 10℃ / -15℃ / -25℃ / -40℃ / -50℃ / -60℃ / -100℃	Utility hot water Heating; Chilled water Ice making; Cold storage, Freezer, Fish boat; Specific Refrigeration needs; Freezer, Freeze-dry, Super Low temp storage	Utility hot water; Chilled water Ice making	Utility hot water Heating HVAC; Cryogenics	Heat recovery; Chiller	Cryogenics
Notes	·Conventional system ·National Projects	·Eco-Cute	·Nat'l Proj. ·Butane + Propane	·Nat'l Proj. ·Adsorption ·Heat recovery	·Nat'l Proj. ·Air-cycle

2008

Five environmentally-friendly Natural Refrigerants applied to Refrigeration, Air Conditioning, Heating and Hot Water Supply





NH3 HP COMPRESSORS

FIELD CASE

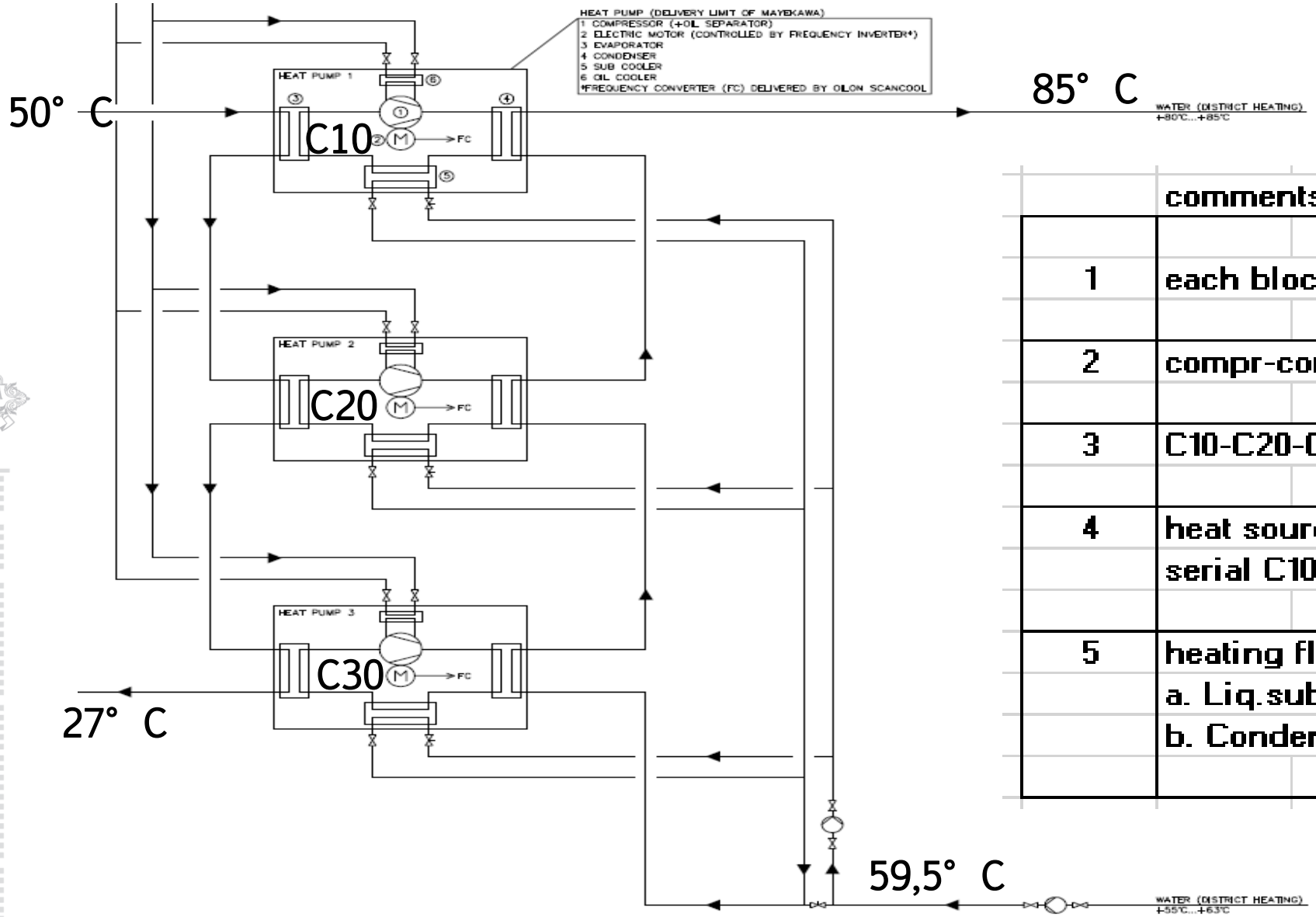
NH3 high pressure heat pump hot water production for district heating

INTRODUCTION

Starting point, need? 4400kW +85° C	Building heating installation by using industrial heat pumps using flue gas heat from an industrial production plant . The new plant, with nominal design capacity 4400 kW hot water of 85° C per hour, is to be used for producing hot water for district heating operating 24hrs/day per workweek : in the different seasons Winter (high season) Spring & Autumn (mid season) Summer (low season)

Why natural refrigerants +88° C +47° C	To produce the water of 85° C NH3 is needed to condens at 88° C(49,1 bara). To use the heat source at max.50° C NH3 is needed to evaporate at max.47° C (12,8 bara)
Which choice & why	NH3 Most suitable NF. NH3 charge max. 500 kg NH3 in the plant. NH3 is standard application for the Contractor.
Timeframe 2016 order ready 2-2017 S.A.T.	 Plant extension had to be executed from October 2016 till February 2017. 21-3-2017

SYSTEM DESIGN DETAILS				REF.SO78287
HEAT OUTPUT	**HOT WATER FOR DISTRICT HEATING**			
	water	outlet	°C	85
		return	°C	59,5
	capacity		kW	4392
HEAT SOURCE	**FLUE GAS**			
	water	inlet	°C	50
		outlet	°C	26
	capacity		kW	3646
COMPRESSORS	type	**high pressure reciprocating**		
	model	**N6HS**		
	quantity	**3**		
DRIVE MOTORS	power	kW	400	C10
VFD		kW	315	C20
		kW	315	c30
NH3	charge	kg	**150**	each
		g/kW	**100**	
	circuit		individual	



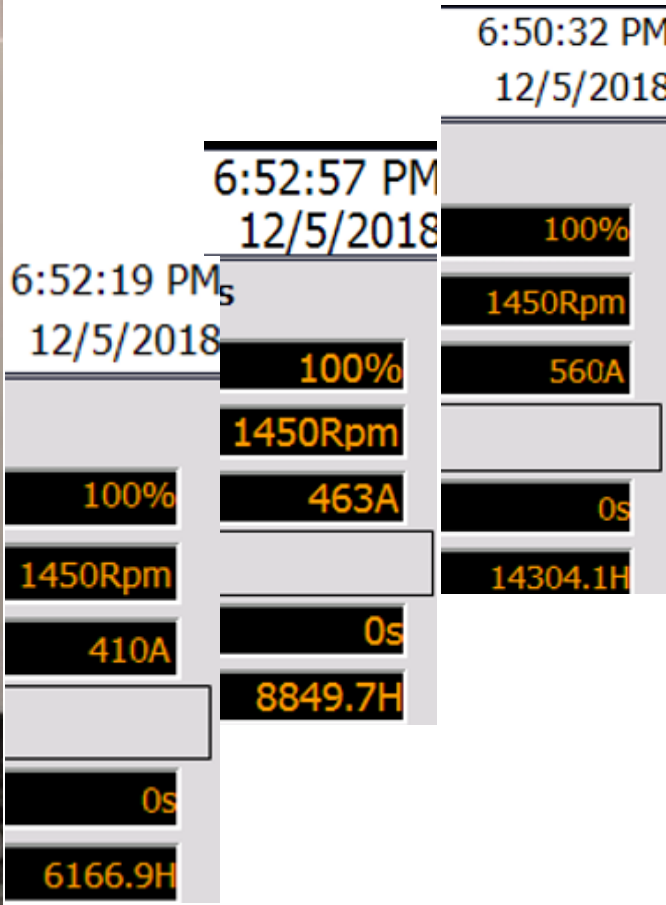
	comments
1	each block = individual NH3 circuit
2	compr-cond-liq.subc-evap
3	C10-C20-C30
4	heat source flow serial C10->C20->C30
5	heating flow a. Liq.subc. in parallel b. Condensors in serial C30->C20->C10

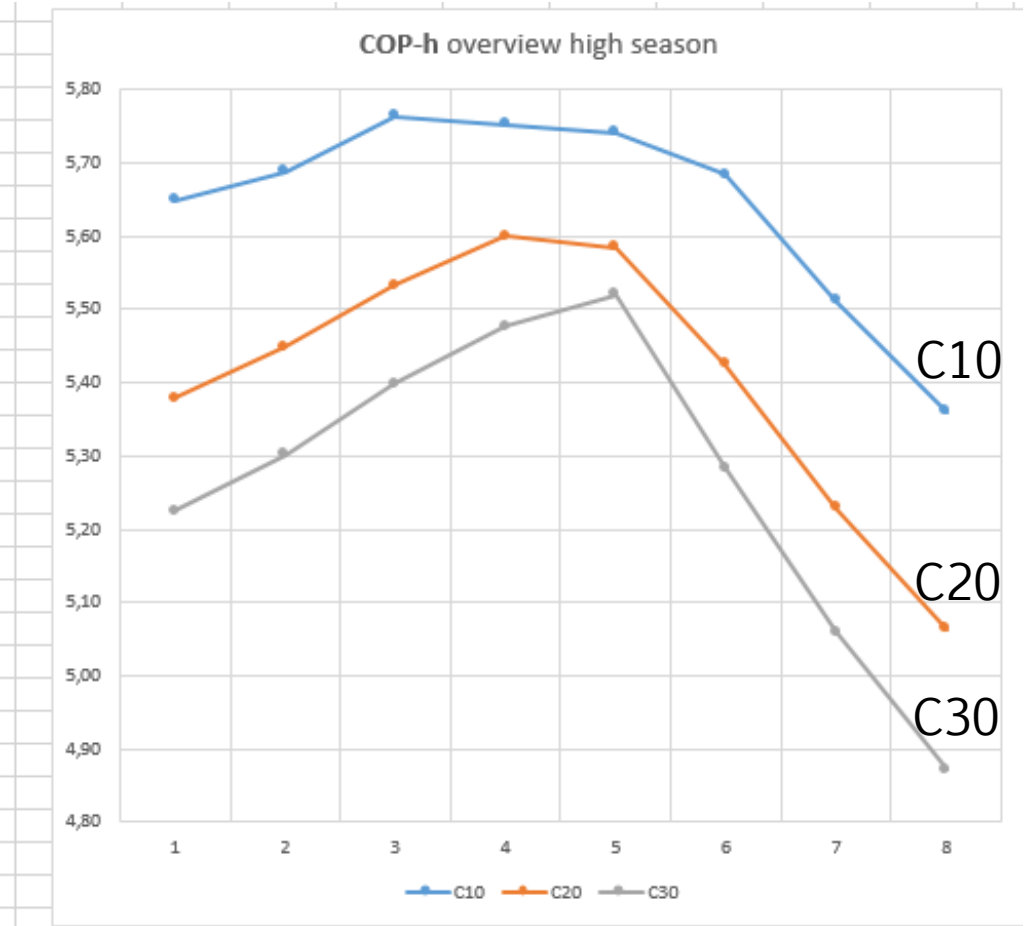
DESIGN DATA

HEAT PUMP		C10	C20	C30	total
TC(PD)	°C(barg)	88(48,1)	79(39,5)	71(32,9)	
TE(PS)	°C(barg)	38(13,7)	30(10,7)	24(8,7)	
SC	°C	24	15	7	
HEATING	kW	1785	1423	1183	4391
BKW	kW	316	264	226	806
COPh		5,65	5,39	5,23	5,45
HEATING WATER					
OUT	°C	85	76	68,5	85
IN	°C	76,1	68,5	61,4	59,5
FLOW	kg/s				41,2
HEAT SOURCE					
IN	°C	50	40,5	32,7	50
OUT	°C	40,5	32,7	26,7	27
FLOW	kg/s				37,9


MAYEKAWA
150 kg NH3
85g/kW
C10


C30
6.167 hrs
C20
8.849 hrs
C10
14.304 hrs
5-12-2018 29.320 hrs
MAYEKAWA


6:50:32 PM
12/5/2018
100%
1450Rpm
560A
0s
14304.1H
6:52:57 PM
12/5/2018
100%
1450Rpm
463A
0s
8849.7H
6:52:19 PM
12/5/2018
100%
1450Rpm
410A
0s
6166.9H



COP-H OVERVIEW

	1	2	3	4	5	6	7	8
%	100	90	76	62	52	43	35	26
C10	5,65	5,69	5,76	5,75	5,74	5,68	5,51	5,36
C20	5,38	5,45	5,53	5,60	5,58	5,42	5,23	5,06
C30	5,22	5,30	5,40	5,48	5,52	5,28	5,06	4,87
RPM	1450	1300	1100	900	750	750	750	750
LOAD%	100	100	100	100	100	83	66	50

HIGH-SEASON (NOV->MARCH : 5 MONTHS)

1450rpm	C10	C20	C30	
QC	1785,5	1423,2	1182,9	4391,6
BKW	316,1	264,6	226,4	807,1
COP-h	5,65	5,38	5,22	**5,44**

1300rpm	C10	C20	C30	
QC	1663,8	1276,5	1060,4	4000,7
BKW	292,5	234,3	200	726,8
COP-h	5,69	5,45	5,30	**5,50**

regime :
3 compressors 100% banks & vfd 1450->1300rpm

MID-SEASON (SEP->OCT,APR.->MAY : 4 MONTHS

rpm		1429		1450	
	C10	C20		C30	
QC	0	1188,0		1081	2269,0
BKW	0	239		197	436,0
		4,97		5,49	**5,20**

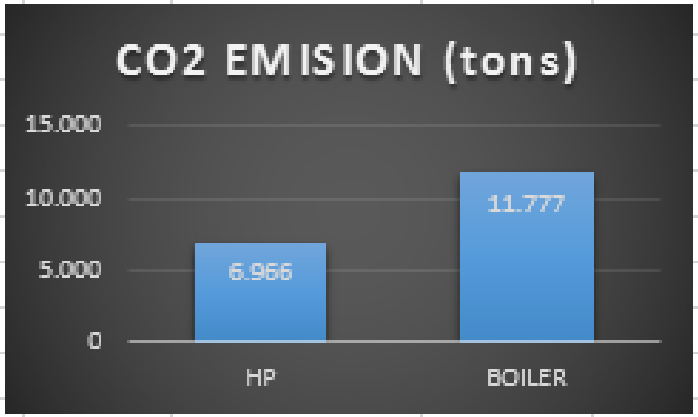
1100rpm	C10	C20		C30	
QC	1356,6	1078,9		0	2435,4
BKW	235,4	195		0	430,4
					5,66

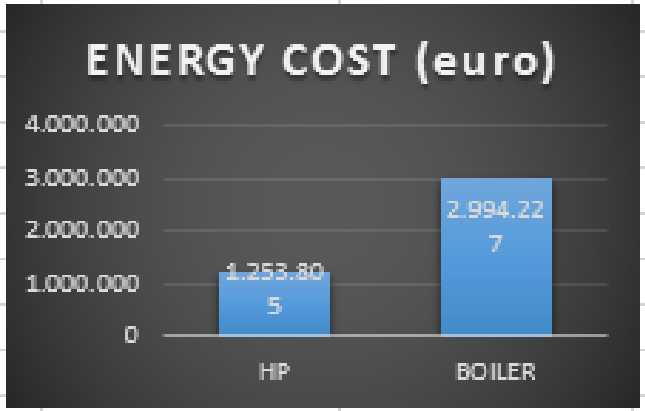
regime :
2 compressors 100% banks & vfd 1450->1100rpm

HEAT PRODUCTION ON YEARLY BASIS

season	rpm vs hours				sum	heating		BKW		COPh	
	hp	C10	C20	C30		per hour	total	per hour	total		
	rpm	hrs	hrs	hrs	hrs	kW	MWh	kW	MWh		
high 5m	1300	3600	3600	3600	10800	4000	43200	727	7852	5,44	5,50
mid 4m	1100	2840	2540	300	5680	2435	13831	430	2442	5,20	5,66
low 3m	750	2011	0	311	2322	1229	2854	224	520	5,49	5,49
	total	8451	6140	4211	18802		59885		10814	5,37	5,55

OPERATING SAVINGS		HEAT PUMP	GAS BOILER	
Performance COPh		4,30	0,90	*
Hot water (year)	mW	59.885	66.538	
Energy consumption (year)	MWh	13.931	66.538	Saving 52.607MWh or 80%
Energy prices	euro/MWh	90	45	
Energy costs	euro	1.253.805	2.994.227	Saving 1.740.422€ or 58%
CO2 emissions	tons	6.966	11.777	Saving 4.811 tons or 40%

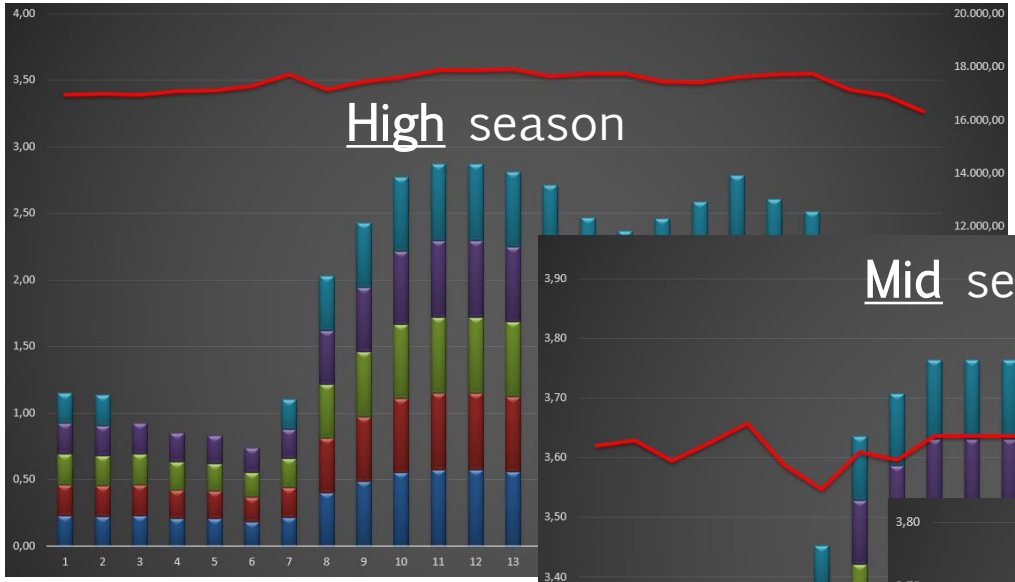




* incl.20% losses on heat pump

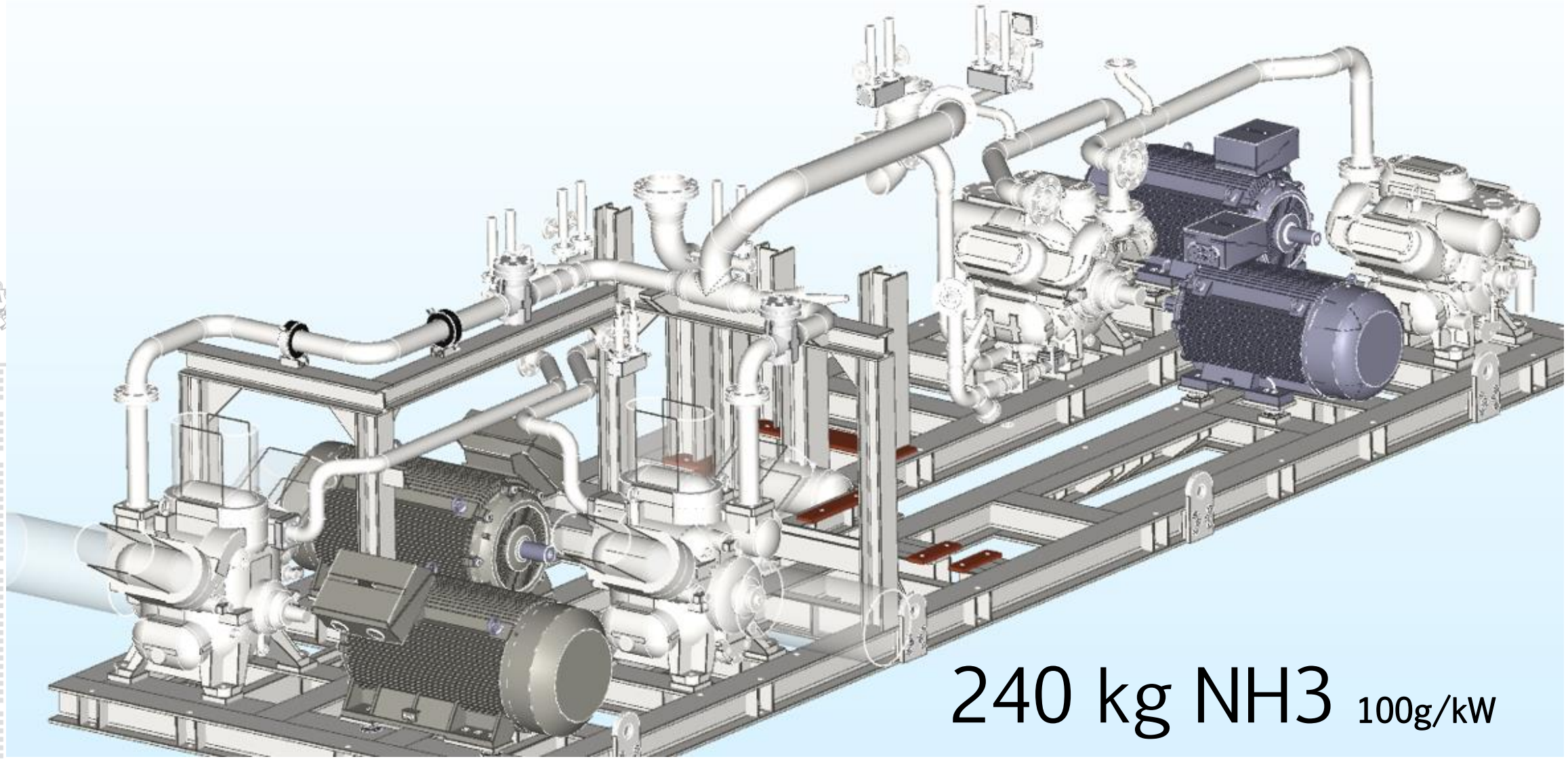
&
NEXT

SEASONAL HEAT LOADS PER HOUR



90 GWh HEATING (yearbasis)

DESIGN DATA		PER SET			6 SETS
HEAT PUMP		1	2	subtotal	total
TC	°C	83	83		
TM	°C	30	30		
SC	°C	20	20		
HEATING	kW	1153	1153	2306	13836
BKW	kW	228	228	456	2736
COPh		5,06	5,06	5,06	
STEP CHILLER		1	2		
TE	°C	3	3		
TM	°C	30	30		
SC	°C	0	0		
COOLING	kW	839	839,0	1678	10068
BKW	kW	112	112	224	1344
COPc		7,49	7,49	7,49	
COPhtotal		3,39	3,39	3,39	3,39
HEATING WATER					
OUT	°C			80	
IN	°C			60	
FLOW	kg/s			27,54	
HEAT SOURCE					
IN	°C			15	
OUT	°C			5	
FLOW	kg/s			40,1	


240 kg NH3 100g/kW

HEAT PRODUCTION ON YEARLY BASIS

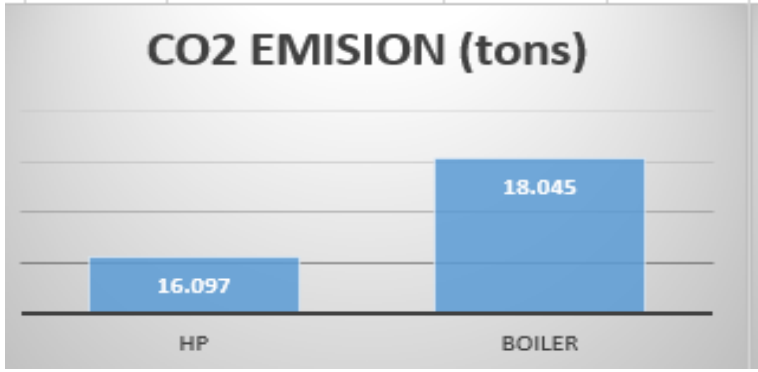
season	month qty	sum hrs	heating per hour kW	heating total MWh	BKW per hour kW	BKW total MWh	COPh
high	3	2160	12098	26132	3457	7467	3,50
mid	6	4320	12722	54959	3524	15224	3,61
low	3	2160	4937	10664	1397	3018	3,53
total	12	8640		91755		25708	3,57

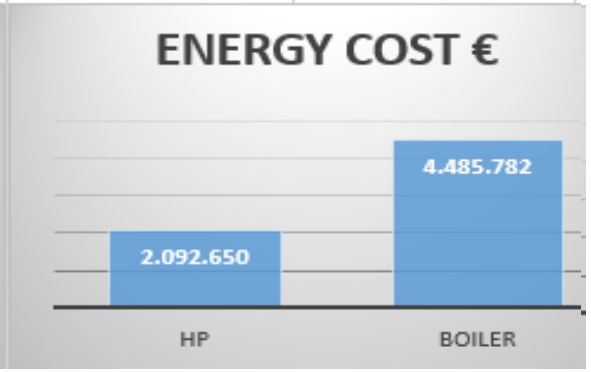
OPERATING SAVINGS		HEAT PUMP	GAS BOILER
Performance COPh		2,85	0,90
Hot water (year)	mW	91.755	101.950
Energy consumption (year)	MWh	32.195	101.950
Energy prices	euro/MWh	65	44
Energy costs	euro	2.092.650	4.485.782
CO2 emissions	tons	16.097	18.045

Saving 69.755 MWh or 68%

Saving 2.393.107€ or 53%

Saving 1.948 tons or 11%





SUMMARY

SAVINGS / YR

HEAT SOURCE	HOT WATER T° °C	OUTPUT INPUT ENERGY MWh/yr COP-h.el	ENERGY MWhr %	ENERGY € %	CO2 tons %
FLUE GAS 50°C	85	60.000 14.000 4,30	52.600 80	1.740.000 58	4.800 40
WATER STATION 5->13°C	80	92.000 32.000 2,85	69.800 68	2.393.100 53	2.000 11


THANKS FOR
YOUR ATTENTION

MARKET AVAILABILITY

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