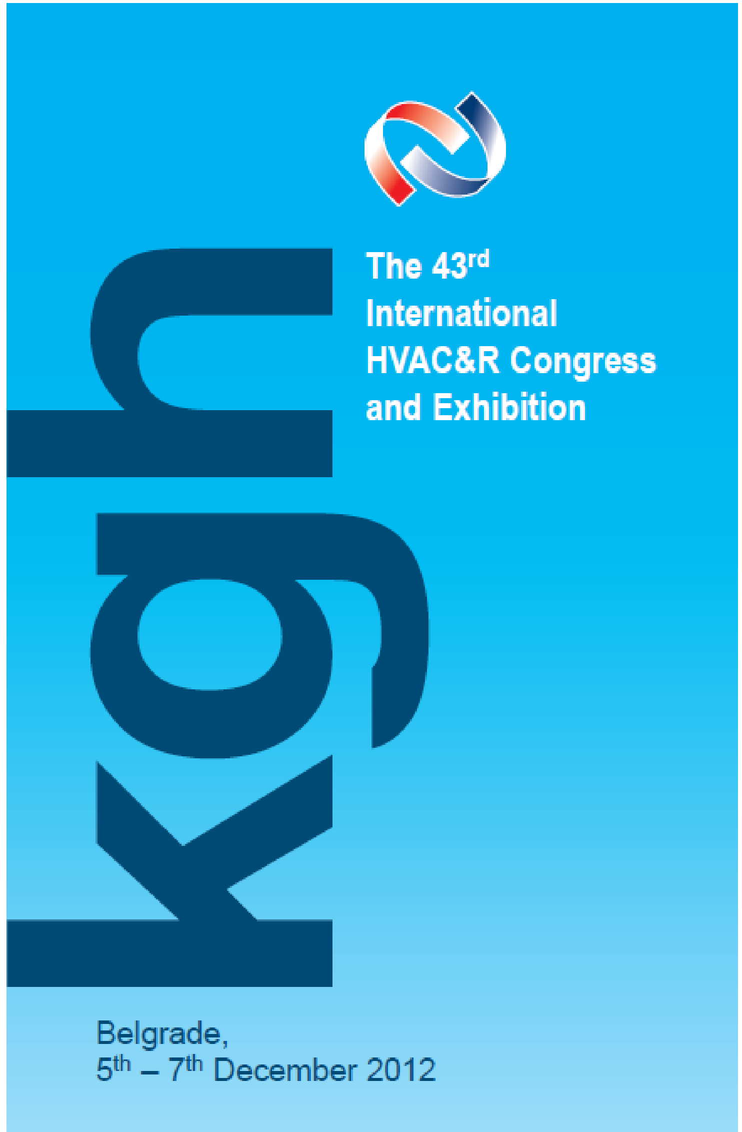

Presented by Jan Boone, MAYEKAWA

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NATURAL 5 LINE-UP

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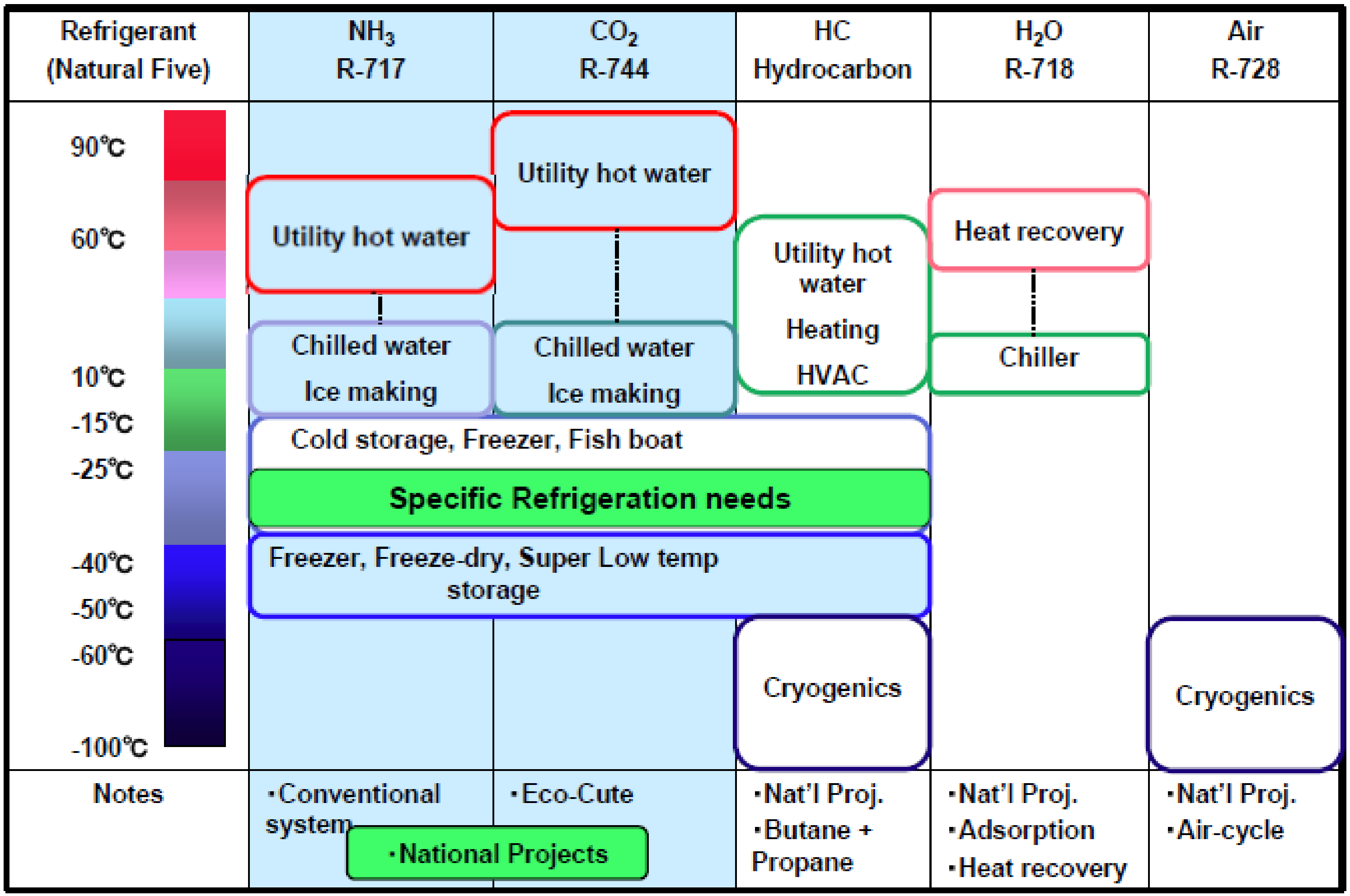
"Natural Five" Refrigerants and Product Solutions



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FIELD CASES :

NATURAL REFRIGERANTS In Different Industrial HEAT PUMP plants in Norway

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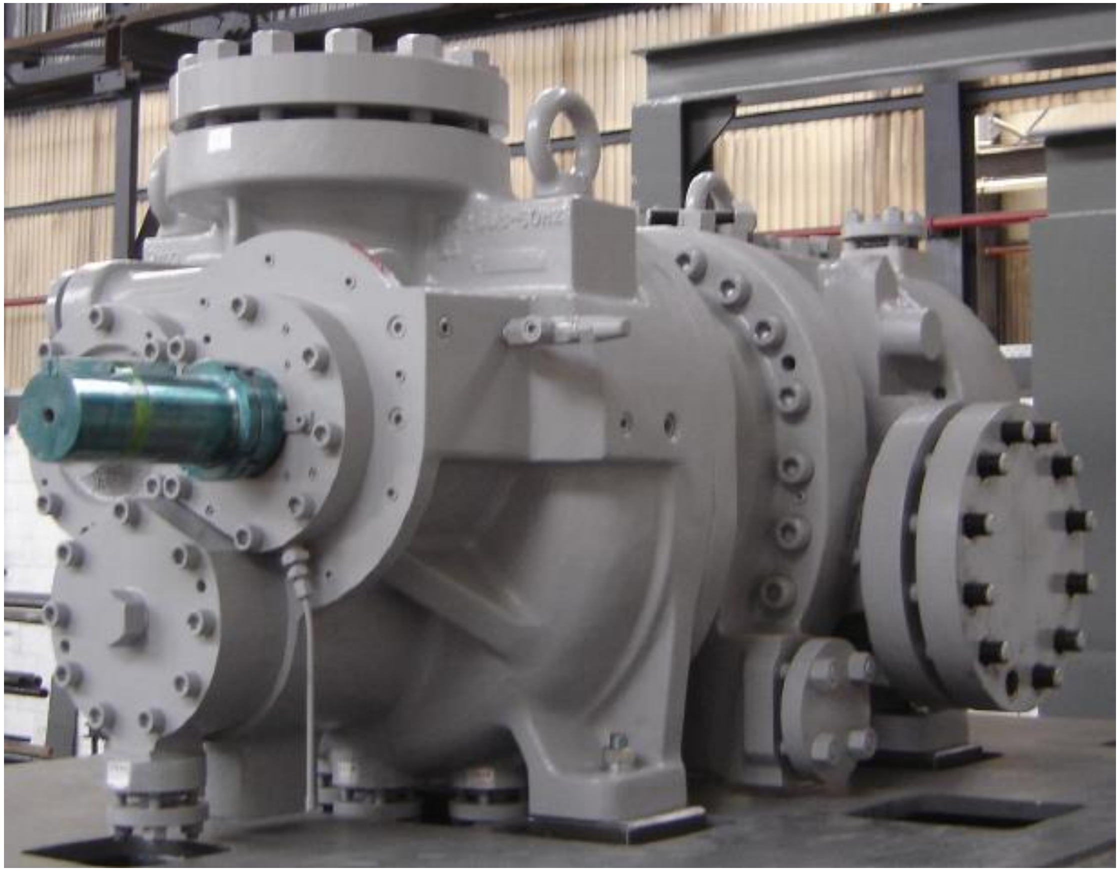
NH3 COMPRESSION HEAT PUMPS



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FIELD CASE 1

TECHNOLOGY AREA – ENERGY STATION – COOLING & HEATING

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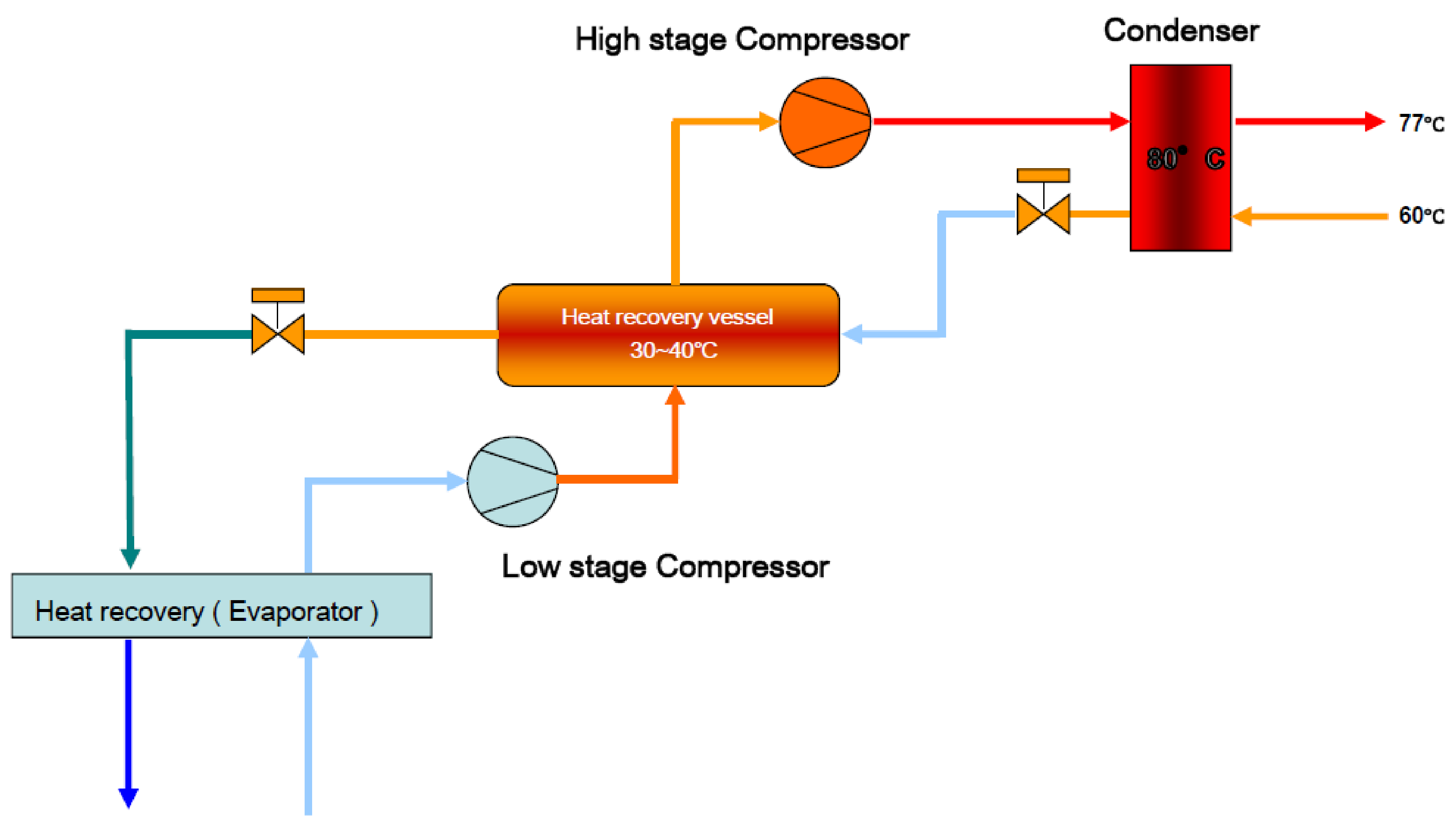
INTRODUCTION

Starting point, need?	The contractor THERMA INDUSTRI has received the request from his customer to install 2 hot water heat pumps, each 1350kW for 77°C.
Heat output ? 2700 kW 77°C	The plant is an energy station of a technology area. The cooling is used to produce ice-water for : Office cooling Cooling for data center The heating is used to produce hot water of maximum 82°C for : District heating
Heat Source ? 30°C to 40°C	Requirements ? Heat source : 1) Heat rejection from the cooling plant needed for office- and process cooling Minimum load : 600 kW Maximum load : 5000 kW 2) Sewage water in case insufficient cooling plant heat rejection available.
Restrictions ?	

->INTRODUCTION

Why natural refrigerants +80°C	For the temperature of 80°C NH_3 is the most suitable refrigerant
Which choice & why	NH_3 (TC=+80°C & PD=39,6barg) as natural refrigerant to obtain 77°C hot water. NH_3 is standard application for Therma Industri.
Timeframe	The project started in 2008. Installation done in 2009.


High stage Compressor
Condenser
80° C
77°C
60°C
Heat recovery vessel
30~40℃
Low stage Compressor
Heat recovery (Evaporator)

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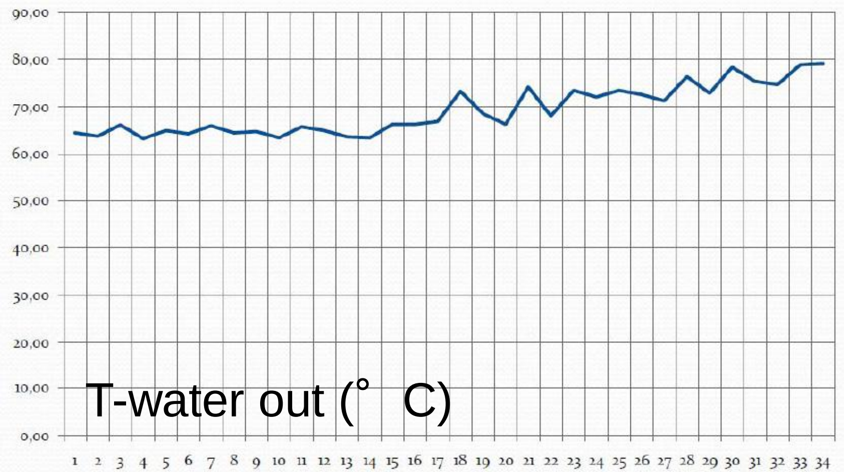
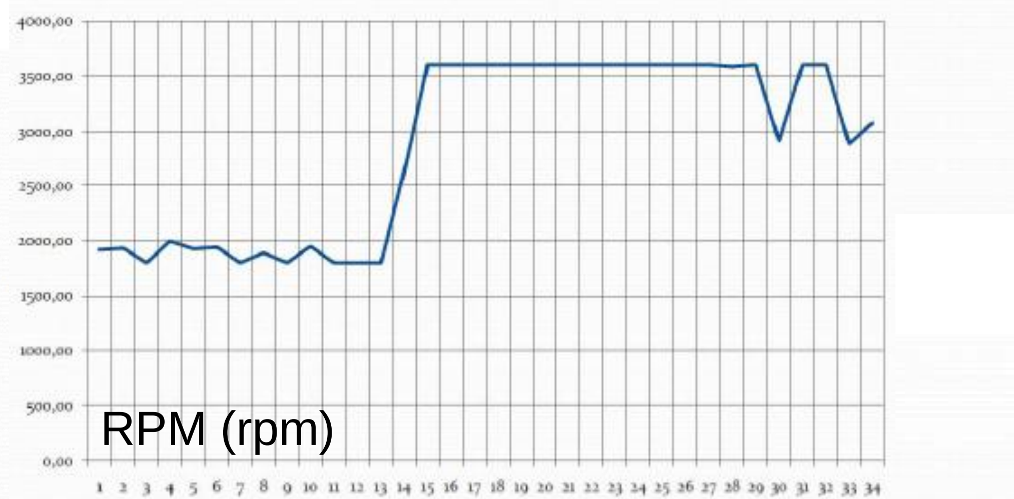
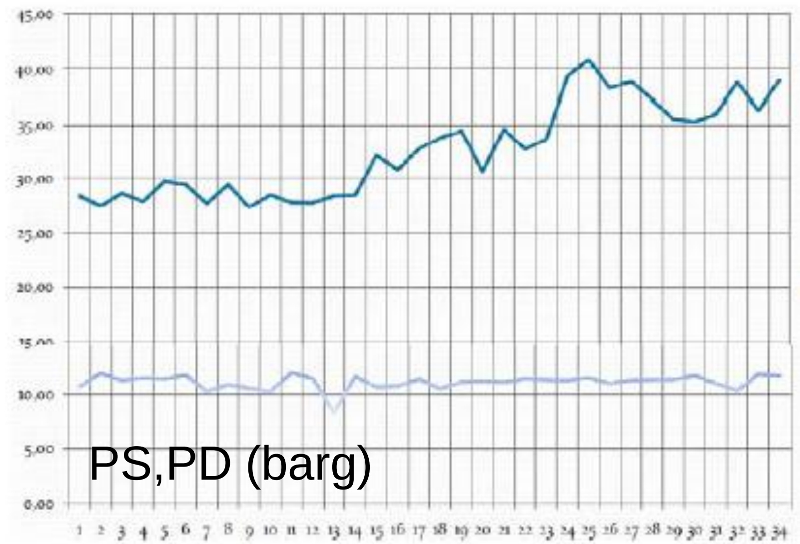
IDENTIFICATION					
COMPRESSOR MODEL			SERIAL NUMBER		UNIT
N160GHS-V			8161006		VP1
N160GHS-V			8161005		VP2
MAIN DRIVE MOTOR			315kW		
QUANTITY			2		
PER MACHINE		**HEAT INPUT**	**POWER INPUT**	**HEAT OUTPUT**	
T	°C	30		77	
	kW	**RT**	**BKW**	**QC**	**COP-h**
RPM	3550	**820**	**266**	**1086**	**4,1**
	1800	**361**	**136**	**497**	**3,7**
T	°C	40		77	
	kW	**RT**	**BKW**	**QC**	**COP-h**
RPM	3550	**1103**	**263**	**1366**	**5,2**
	1800	**471**	**134**	**605**	**4,5**

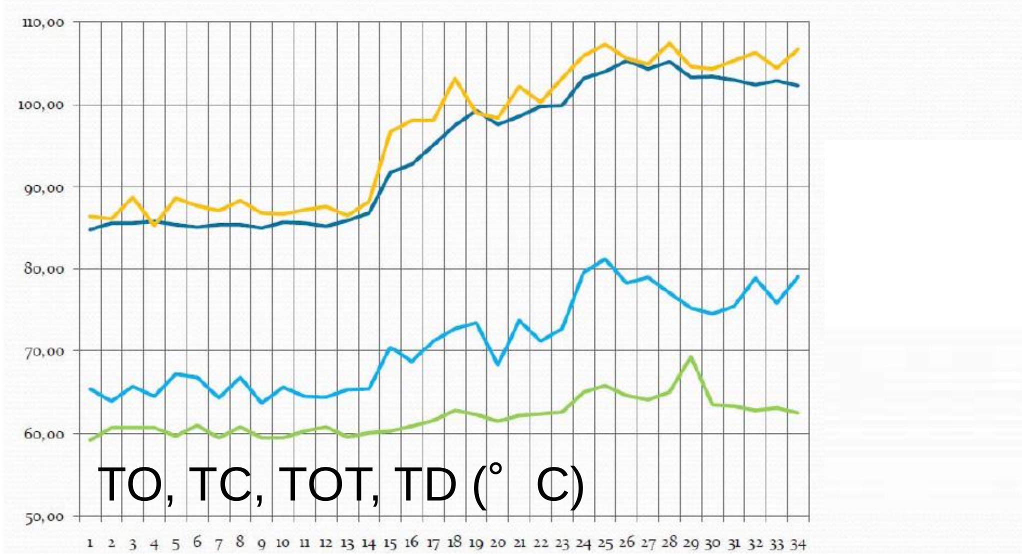
T	°C	temperature	(heat input : NH3, heat output : hot water)
RT	kW	heat source capacity	
BKW	kW	absorbed motor power at shaft	
QC	kW	heat output capcity	
COP-h		coefficient of heating performance	
RPM	rpm	shaft revolution per minute	

LOGGING DATA









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EFFICIENCY ANALYSIS

Difference planned & actual results if occured?	
If yes, why were there differences?	The plant produced approx. 10 GWh of energy in 2010, which increased to 13 GWh in 2011. The design COP-h is in the range of 3.7 to 5.2 depending on the plant load. The yearly overall COP-h was above 3 for the first 3 years of operation.
How is the process of measuring efficiency?	The equipment is operating following load programs which must be covered by the heating plant, which was fullfilled. The machines are equipped with frequency convertor for speed control at part-load operation in order to keep the best COP-h

HEAT SOURCE / HEAT OUTPUT / COP-heating overview

							HEAT SOURCE		extra compressor N200VL-L		COP-final	
TE °C	TM °C	TC °C	RT kW	QTY	QC kW	BKWhp kW	data center kW	sewage water kW	rt kW	bkw kW	BKWt kW	cop-total QC/BKWt
4	40	80	2206	2	2732	526	600	1606	1360	246	772	3,5

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BARRIERS & SOLUTIONS

WHAT BARRIERS WERE WE FACING WITH THIS PROJECT & HOW SOLVED ?	
Technical problems or availability of systems, components, engineers?	As this plant was one of the first in Europe realised, supply and availability of high pressure components has been one of the faced bottle necks. Thanks to the customer who gave full confidence and made strong investment in this new technology to Therma Industri it was possible to succeed and realise this plant with success !
Psychological barriers from customer:management?	Not as customer fully relied on the capability Therma & Mycom.
Safety problems, legilative barriers?	The plant/system was build fully in compliance with CE-PED.
Short term cost differences?	Not

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LESSONS LEARNED

WHAT HAS BEEN LEARNED FROM THE PROJECT & HOW CAN THIS BE APPLIED TO OTHER PROJECTS USING NR.	
What will you do different in the future?	For the refrigeration/heating plant, the customer will go for the same solution as demonstrated by this field case which is already running nearly 15.000hrs with full satisfaction !
What can you apply to the next project?	

FUTURE PLANS

Have you planned or do you know about similar projects?	
What are your recommendations for the planning, design etc. Of NR systems ?	Continue in the same line. Therma Industri has more than 25 NH_3 hp plants in operation which have been installed since 1998 !

FIELD CASE 2

SLAUGHTERHOUSE – HOT WATER PRODUCTION

INTRODUCTION

Starting point, need?	**The plant is a Norvegian slaughterhouse existing since 1950, with about 30 plants in operation.** **In 1987 a centralisation and modernisation of the sites took place with NH3 as preferred refrigerant.** **Since 1989 NH_3 compression heat pumps are used for production of 50°C water for 1200kW.** **In 2007 a hybrid heat pump was installed for 500kW.**
Requirements 2009? **2400kW 52°C**	**As there was an important need for more hot water because of production extension,** **it was decided to increase the hot water production with an additional 2400 kW.** **The contractor THERMA INDUSTRI received the request to install 2 sets MYCOM NH_3 overcompression heat pump screw compressors.**

->INTRODUCTION

Why natural refrigerants +52°C	
Which choice & why	NH_3 (TC=+57°C & PD=23 barg) as natural refrigerant to obtain 52°C hot water. Heat source : rejected condensor heat from refrigeration plant 'VERY EFFICIENT' 'CHEAP' 'EXPERIENCE SINCE 1950' NH_3 is standard application for THERMA INDUSTRI.
Timeframe 2009 idea Re-built & Extend? 2011 ∑ 9 wks	The project started in 2009. Followed by some budgetting time. Installation done in 2011 - building out old equipment : 1 week - building in completed after 8 weeks ! Start-up OCTOBER 2011.

FUNDING

Funding, partner : other organisation	**YES** **NORWEGIAN ENERGY ORGANISATION** **ENOVA** **900.000 NOK**
	This new heat pumps save 1,6 GW fuel per year (approx. 210.000 liter). 'The funding is only valid on condition that savings were realised ! After 7 months of operation it was already visible that the 1,6 GW was going to be realised easily !'

EQUIPMENT

COMPRESSORS	**NH3 SCREW COMPRESSOR PACKAGES COMPLETE WITH OIL SYSTEM AND CONTROLS.** **Producing NH_3 at 57°C (saturated condensing temp.) from NH_3 heat source at 20°C (saturated evaporating temp.) to make hot water of 52°C.** **This hot water is than further heated by other equipment to 84°C and buffered in a 200.000 liter tank.**
MODULATING CONTROL VALVE	The suction pressure of the heat pumps is controlled at 7,5 barg (20°C), Representing an important saving of energy on the refrigeration plant : COPc 50% better at least -10/+35°C RT/BKW/COPc=353kW/105kW/3.36 -10/+20°C RT/BKW/COPc=381kW/ 73 kW/5.21. (256MW power saving on 8000hrs) Priority is given to the heat pumps, normally the external condensor is not active.
FREQUENCY CONTROL	The screw compressors are equipped with frequency convertors which result in no reactive power, Saving 8.000 NOK monthly (or x12 = 96.000 NOK per year) The FC drive engines are more expensive but quickly payd back. 'this was a bonus'

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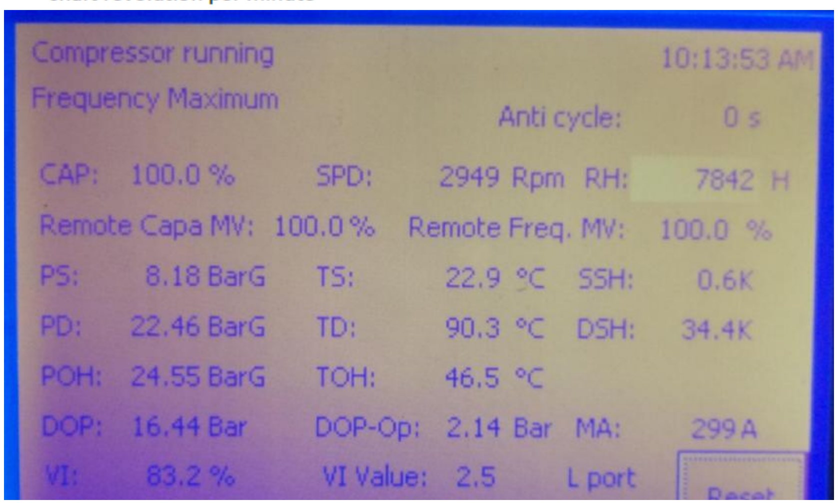
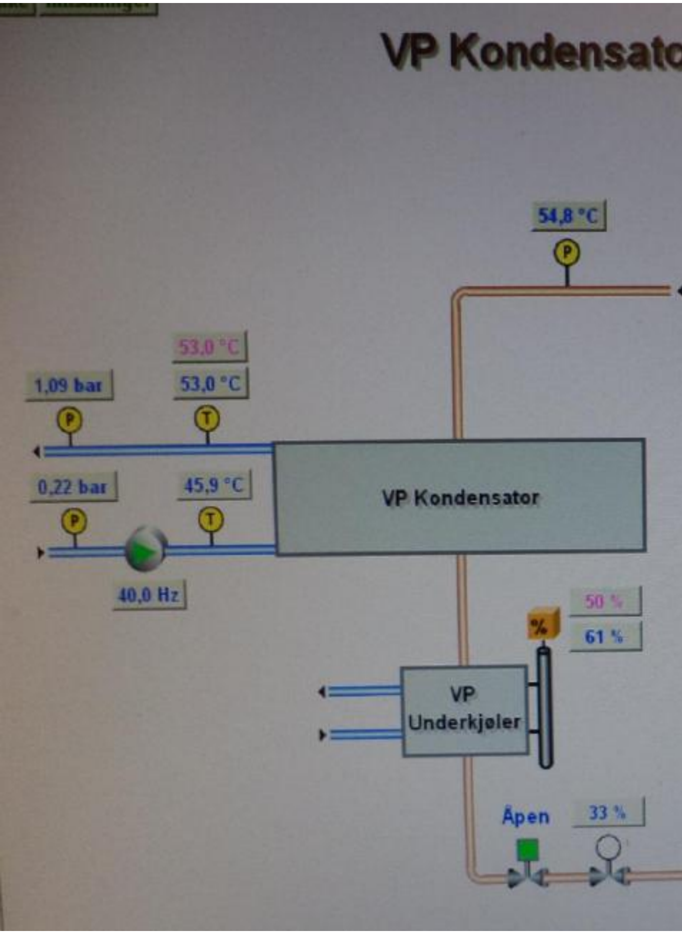
IDENTIFICATION					
COMPRESSOR MODEL		SERIAL NUMBER			UNIT
N170JM-L		1731020			VP1
N170JM-L		1731010			VP2
MAIN DRIVE MOTOR		250kW			
QUANTITY		2			
PER MACHINE		**HEAT INPUT**	**POWER INPUT**	**HEAT OUTPUT**	
T	°C	20		52	
	kW	**RT**	**BKW**	**QC**	**COP-h**
RPM	3400	**971**	**186**	**1157**	**6,2**
	2950	**835**	**162**	**997**	**6,2**
	1500	**403**	**85**	**488**	**5,7**

T	°C	temperature (heat input : NH3, heat output : hot water)
RT	kW	heat source capacity
BKW	kW	absorbed motor power at shaft
QC	kW	heat output capcity
COP-h		coefficient of heating performance
RPM	rpm	shaft revolution per minute




VP Kondensato
54,8 °C
53,0 °C
1,09 bar
53,0 °C
0,22 bar
45,9 °C
VP Kondensator
40,0 Hz
50 %
61 %
VP
Underkjøler
Åpen
33 %

EFFICIENCY ANALYSIS

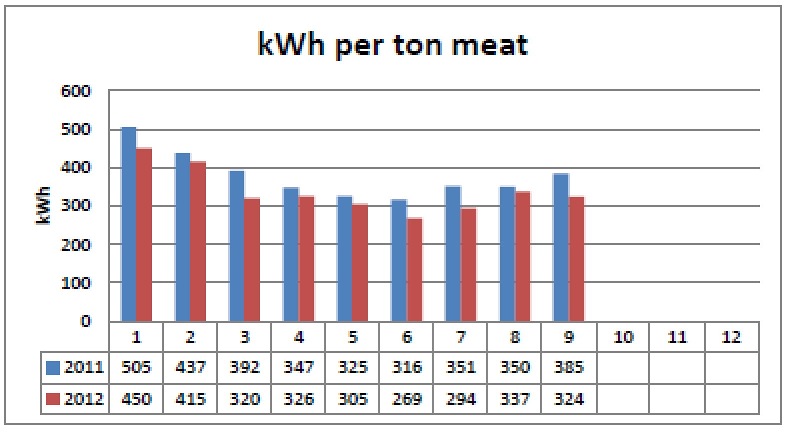
Difference planned & actual results if occured?	
If yes, why were there differences?	The design COP-h is in the range of 5.7 to 6.2 depending on the plant load. The average COP-h was at 5,5 for the first 11 months of operation.

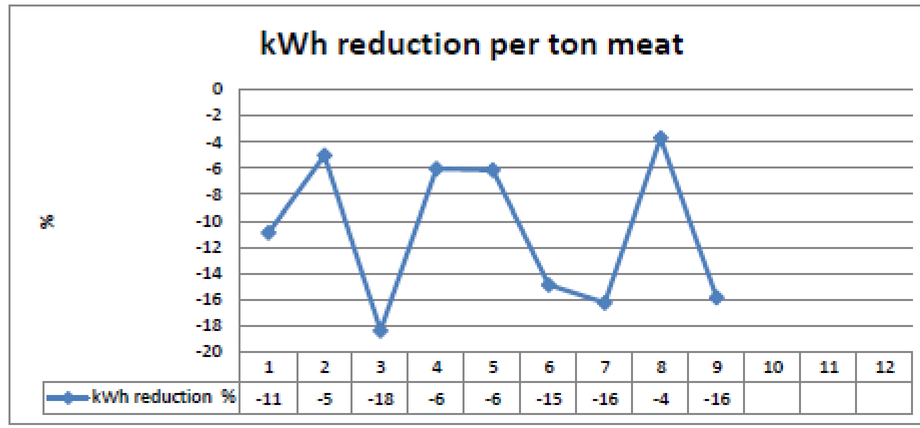
DESIGN WEEKLY mWh				
HRS		276		12997 hrs in 11 months (47 wks)
RPM	BKW	QC	COP-h	
3400	51	319	6,2	
2950	45	275	6,2	
1500	23	135	5,7	

MEASURED REAL OUTPUT/INPUT mWh					
	BKW	QC	COP-h		
MAY	35	190	5,4		
JAN	41,55	232	5,6		

EFFICIENCY ANALYSIS

Difference planned & actual results if occured?	
How is the process of measuring efficiency?	Total power input and heat pump output are checked weekly And taken up in the monthly energy cost per ton of meat which is the basic indicator for the process.





COST ANALYSIS

COSTS INVOLVED	**This installation represents a value of 3.500.000 NOK.** **Includes :** **NH_3 Heat pump installation** **Condensor** **Subcooler** **Waterpumps etc.**
COST SAVING	1,6 GW fuel (210.000 liter equivalent 1.260.000 NOK) TC=20°C (up to 256 MW/yr or 288.000 NOK) FC drivers (96.000 NOK/yr)

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->COST ANALYSIS

Savings or potential savings because of existing or pending regulation	-heat recovery overcompression heat pump uses refrigeration plant heat rejected to the condensor, incl.oil cooler heat rejection -high efficiency electrical motors IE2 motors are applied -frequency controllers compressors and waterpumps -energy-saving condensors

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->COST ANALYSIS

Potential savings in the future	**Improvement is possible by increasing the ammonia condensing temperature from 57°C to 62°C, requiring a 30 bar safety valve setting on the heat pump unit.** **With the old heat exchangers drain water heat is recovered in the 45°C buffer. In the future this heat exchanger can be replaced with a more efficient execution .**
Did forecast succeed/expectations were met?	**The customer is absolutely happy with the plant** 

BARRIERS & SOLUTIONS

WHAT BARRIERS WERE WE FACING WITH THIS PROJECT & HOW SOLVED ?	
Technical problems or availability of systems, components, engineers?	Thanks to the customer who gave full confidence and made strong investment in this new technology to Therma Industri it was possible to succeed and realise this plant with success !
Psychological barriers from customer:management?	Not as customer prefered NH_3 as natural refrigerant since long time and fully relied on the capability Therma Industri for the heat pump technology.
Safety problems, legilative barriers?	The plant/system was build fully in compliance with CE-PED.

LESSONS LEARNED

WHAT HAS BEEN LEARNED FROM THE PROJECT & HOW CAN THIS BE APPLIED TO OTHER PROJECTS USING NR.	
What will you do different in the future?	For the refrigeration/heating plant, the customer will go for the same solution as demonstrated by this field case !
What can you apply to the next project?	Higher safety valve set pressure to allow operation with higher water output temperatures.

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ACTION PLAN

IDEAS OF CONCRETE ACTIONS TO GET NATURAL REFRIGERANTS FASTER TO EUROPE :	
1.1. What are the concrete actions already done ?	Mayekawa only promotes natural refrigerants since the beginning of this century.
1.2. Or/and planning to do ?	
2.1. what kind of actions needed to expand NR systems, for : Technology, Training, Safety, Policy, Standards, Regulation, Market, Costs, End-users.	Unlimited development ongoing. With each new product:system neccessary trainings are also made available. Suppliers of refrigeration accessories (EN378 qualified) should make more products available for high pressure/big size duty. Mayekawa still have too often to rely on expensive accessories designed for oil and gas industry.

CONCLUSION

NATURAL REFRIGERANTS SOLUTIONS FOR EUROPE :

THIS PROVEN FIELD EXAMPLE SHOWS THAT THE SUCCESS OF THE NEW TECHNOLOGY IS MUCH DEPENDING ON THE QUALITY OF THE PREPARATIONS DONE ON BEFOREHAND FOLLOWED BY THE INSTALLATION AND COMMISIONING WITH OPTIMAL FINE TUNING, FROM COOPERATION BETWEEN ALL PARTIES INVOLVED :

MANUFACTURER : MAYEKAWA JAPAN/ MAYEKAWA EUROPE
CONTRACTOR : THERMA INDUSTRI.

The 43rd International HVAC&R Congress and Exhibition

Belgrade,
5th – 7th December 2012

THANKS FOR YOUR ATTENTION !

& much appreciated thanks to
the Contractor of the fieldcases :

THERMA INDUSTRI AS

NORWAY
Mr.Stein Terje Brekke(stein.brekke@therma.no)
Mr.Stein Johnsen (stein.johnsen@therma.no)

Presented by Jan Boone, MAYEKAWA

MAYEKAWA Europe nv/sa

kgh

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d.o.o. KLIMA
SMEDEREVO
tel./fax 026 / 221-715, www.klima.co.rs

Presented by Jan Boone, MAYEKAWA

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WORLDWIDE
- 36 countries / 122 offices
- 8 production plants

Europe Organization

SWITZERLAND
Rosenbergstrasse 31, 6300 Zug
Tel. +41 41 726 8626
Fax +41 41 726 8620
http://www.mayekawa.ch
E-mail info@mayekawa.ch

SPAIN
Calle Montevideo 5, Nave 13
Pol. Industrial Camporroso
28806 Alcala de Henares, Madrid
Tel. +34 91 830 0392
Fax +34 91 830 0397
http://www.mayekawa.es
E-mail mayekawa@mayekawa.es

GERMANY
Munich Office
Untere Bahnhofstrasse 38a, 82110 Germering
Tel. +49 89 5527 989 0
Fax +49 89 5527 989 19
Hamburg Office
Weidestraße 122a, 22083 Hamburg
Tel. +49 40 2788914 9 0
Fax +49 40 2788914 9 9
E-mail info@mayekawa.de

FRANCE
East Branch Office
9, Rue Michael Faraday
78180 Montigny-Le-Bretonneux
Tel. +33 1 30 58 26 00
Fax +33 1 30 58 19 37
West Branch Office
6, Square des Pruniers
22400 Lamballe
Tel. +33 2 96 76 59 13
Fax +33 1 30 58 19 37
E-mail mayekawa.france@mayekawa.eu

UNITED KINGDOM
16 Oakhurst Gardens
DA7 5JP Bexleyheath, Kent
Tel. +44 1322 433558
Fax +44 1322 433164

RUSSIA
House 3, Flat 54, Mytnaya St.
119049 Moscow
Tel. +7 499 230 01 76
Fax +7 499 230 21 12
http://www.mayekawa.ru
E-mail info@mayekawa.ru

BULGARIA
Kamen Andreev Str. 24, 1303 Sofia
Tel. +359 2 8910130
Fax +359 2 8910131

DUBAI
P.O.Box 61349, LOB. 11. No.126
Jebel Zone, Dubai, U.A.E
Tel. +971 4 887 2232
Fax +971 4 887 2239

INDIA
Mayekawa India PVT. LTD.
309, Centrum Plaza, Golf Course Road
Sector-53, Gurgoan
Haryana
Tel. +91 124 4209811 16
Fax +91 124 4209818

AUSTRALIA
Unit 2, 44 McCauley Street
NSW 2036 Matraville
Tel. +61 2 9695 7000
Fax +61 2 9695 7001
http://www.mayekawa.com.au
E-mail mycomaus@mayekawa.com.au

NEW ZEALAND
Unit 2, 30 Tui Street Otahuhu
Auckland
Tel. +66 9 276 2305
Fax +66 9 276 2306
E-mail info@mayekawa.co.nz

ITALY
Via Riccardo Lombardi 19/12
20153 Milano
Tel. +39 2 489 29216
Fax +39 2 4531728

TURKEY
Dunya Ticaret Merkezi
A/2 Blok Kat:10 No:325 Yesilkoy Istanbul
Tel. +90 212 465 36 31 34
Fax +90 212 465 36 35

JAPAN HEAD OFFICE
3-14-15 Botan Koto-ku
Tokyo 135 8482, JAPAN
Tel. 81 3 3642 8181
Fax 81 3 3643 7094
E-mail e-public@mayekawa.co.jp

MAYEKAWA Europe nv/sa
Leuvensesteenweg 605
1930 Zaventem - Belgium
Tel. +32 2 757 90 75
Fax +32 2 757 90 23
http://www.mayekawa.eu
E-mail info@mayekawa.eu

Global web site
http://www.mayekawa.com/