



Solutions for Europe

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**natural refrigerants**

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**5 – 7 November 2012 in Brussels**

**MAYEKAWA**

**MAYEKAWA Europe nv/sa**

Presented by Jan Boone, MAYEKAWA

# NATURAL 5 LINE-UP

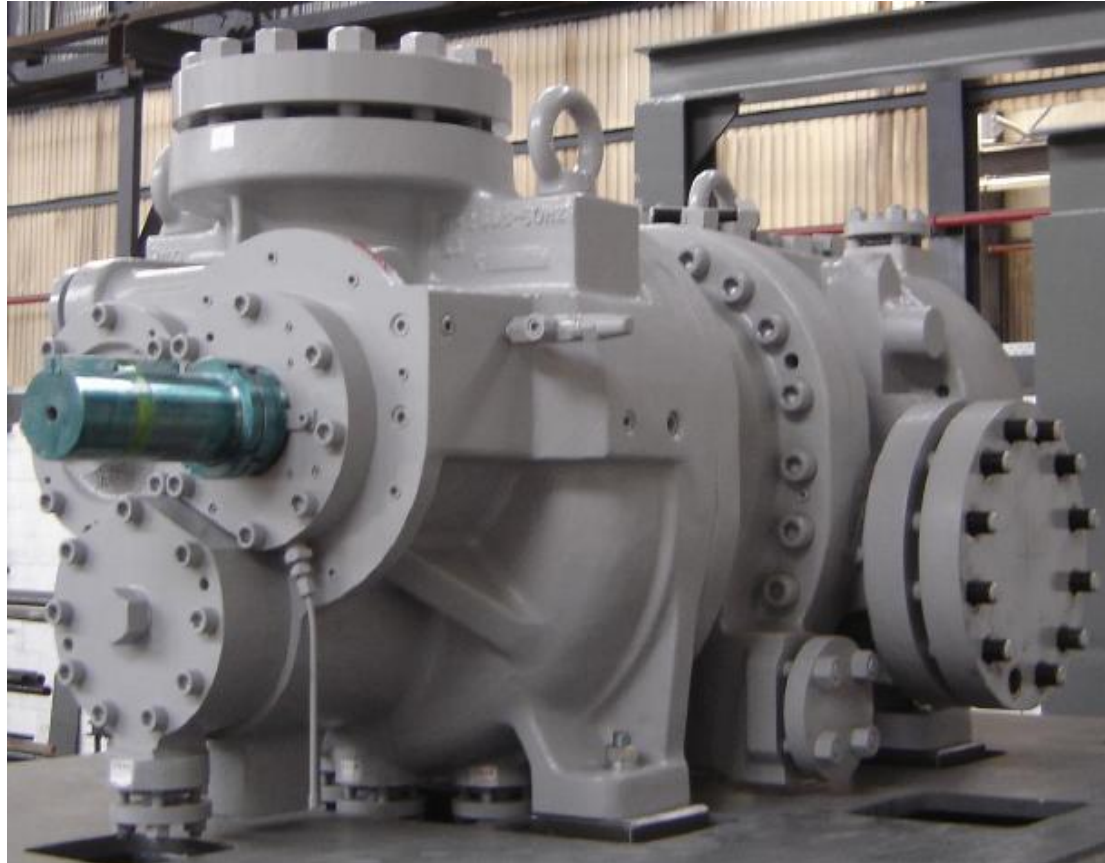
## "Natural Five" Refrigerants and Product Solutions

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

# FIELD CASES :

## NATURAL REFRIGERANTS In Different Industrial HEAT PUMP plants in Norway

# NH3 COMPRESSION HEAT PUMPS



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# FIELD CASE

SLAUGHTERHOUSE – HOT WATER PRODUCTION

# INTRODUCTION

## Starting point, need?

The plant is a Norwegian slaughterhouse existing since 1950, with about 30 plants in operation.

In 1987 a centralisation and modernisation of the sites took place with NH<sub>3</sub> as preferred refrigerant.

Since 1989 NH<sub>3</sub> 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 modernisation & 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<sub>3</sub> overcompression heat pump screw compressors.

## ->INTRODUCTION

|                          |                                                                                                                                                            |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Why natural refrigerants |                                                                                                                                                            |
| +52°C                    |                                                                                                                                                            |
| Which choice             | NH <sub>3</sub> (TC=+57°C & PD=23 barg) as natural refrigerant to obtain 52°C hot water.<br>Heat source : rejected condensor heat from refrigeration plant |
| & why                    | <p>'VERY EFFICIENT'</p> <p>'CHEAP'</p> <p>'EXPERIENCE SINCE 1950'</p> <p>NH<sub>3</sub> is standard application for THERMA INDUSTRI.</p>                   |
| Timeframe                | The project started in 2009.<br>Followed by some budgetting time.<br>Installation done in 2011                                                             |
| 2009 idea                | - building out old equipment : 1 week                                                                                                                      |
| Re-built &               | - building in completed after 8 weeks !                                                                                                                    |
| Extend?                  | Start-up OCTOBER 2011.                                                                                                                                     |
| 2011 Σ 9 wks             |                                                                                                                                                            |

## FUNDING

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

## EQUIPMENT

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| COMPRESSORS              | <p>NH3 SCREW COMPRESSOR PACKAGES COMPLETE WITH OIL SYSTEM AND CONTROLS.</p> <p>Producing NH<sub>3</sub> at 57°C (saturated condensing temp.) from NH<sub>3</sub> heat source at 20°C (saturated evaporating temp.) to make hot water of 52°C.</p> <p>This hot water is than further heated by other equipment to 84°C and buffered in a 200.000 liter tank.</p>                                                |
| MODULATING CONTROL VALVE | <p>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 :<br/>COPc 50% better at least</p> <p>-10/+35°C RT/BKW/COPc=353kW/105kW/3.36<br/>-10/+20°C RT/BKW/COPc=381kW/ 73 kW/5.21.<br/>(256MW power saving on 8000hrs)</p> <p>Priority is given to the heat pumps, normally the external condensor is not active.</p> |
| FREQUENCY CONTROL        | <p>The screw compressors are equipped with frequency convertors which result in no reactive power,<br/>Saving 8.000 NOK monthly (or x12 = 96.000 NOK per year)<br/>The FC drive engines are more expensive but quickly paid back.<br/>'this was a bonus'</p>                                                                                                                                                   |



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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 capacity

COP-h           coefficient of heating performance

RPM      rpm      shaft revolution per minute

|                    |            |                  |          |        |        |                 |
|--------------------|------------|------------------|----------|--------|--------|-----------------|
| Compressor running |            |                  |          |        |        | 10:13:53 AM     |
| Frequency Maximum  |            |                  |          |        |        | Anti cycle: 0 s |
| CAP:               | 100.0 %    | SPD:             | 2949 Rpm | RH:    | 7842 H |                 |
| Remote Capa MV:    | 100.0 %    | Remote Freq. MV: | 100.0 %  |        |        |                 |
| PS:                | 8.18 BarG  | TS:              | 22.9 °C  | SSH:   | 0.6K   |                 |
| PD:                | 22.46 BarG | TD:              | 90.3 °C  | DSH:   | 34.4K  |                 |
| POH:               | 24.55 BarG | TOH:             | 46.5 °C  |        |        |                 |
| DOP:               | 16.44 Bar  | DOP-Op:          | 2.14 Bar | MA:    | 299 A  |                 |
| VI:                | 83.2 %     | VI Value:        | 2.5      | L port |        |                 |

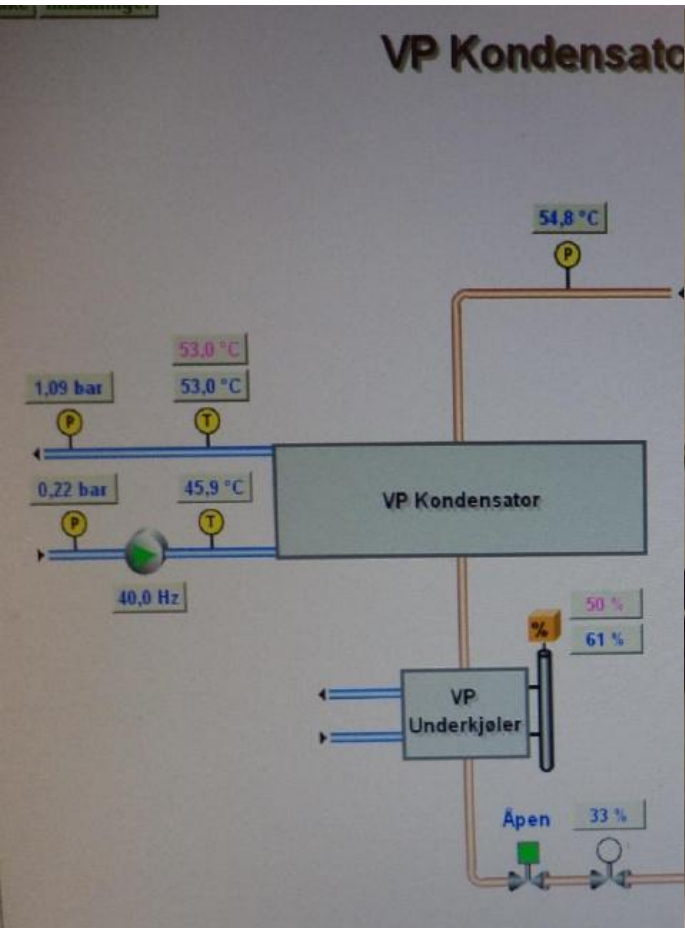


**OPERATING HOURS 3-10-2012 :**  
**VP1 : 5155 hrs      VP2: 7842 hrs**

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## EFFICIENCY ANALYSIS

Difference planned & actual results if occurred?

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.  
(Compared to classic boiler: saving of 85% input energy!)

| 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   |  |  |
|                                |       |     |       |  |  |

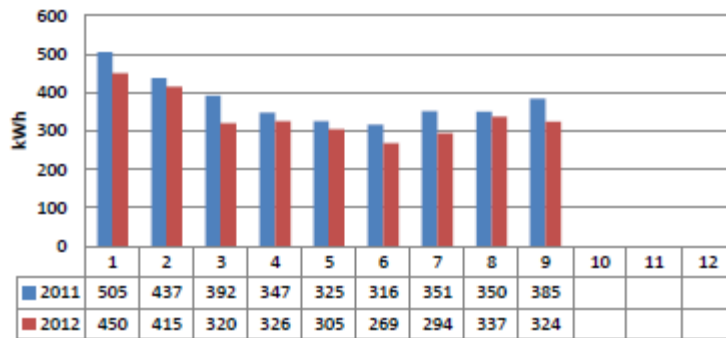
## EFFICIENCY ANALYSIS

Difference planned & actual results if occurred?

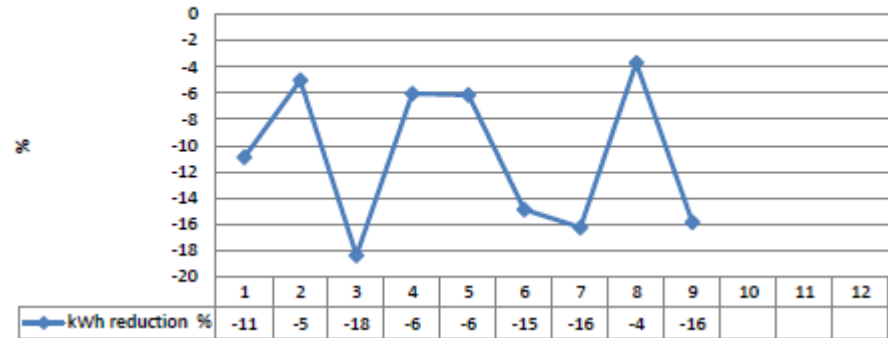
How is the process of measuring efficiency?

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.

kWh per ton meat



kWh reduction per ton meat



## COST ANALYSIS

|                |                                                                                                                                                             |                                                                   |                                     |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------------|
| COSTS INVOLVED | This installation represents a value of 3.500.000 NOK.<br>Includes :<br>NH <sub>3</sub> Heat pump installation<br>Condensor<br>Subcooler<br>Waterpumps etc. | 3.500.000 NOK                                                     |                                     |
| FUNDING        | ENOVA 900.000 NOK                                                                                                                                           | -900.000 NOK                                                      | 2.600.000 NOK                       |
| COST SAVING    | 1,6 GW fuel (210.000 liter equivalent<br>1.260.000 NOK)<br><br>TC=20°C (up to 256 MW/yr or 201.000 NOK)<br><br>FC drivers (96.000 NOK/yr)                   | 1.260.000 NOK/yr<br><br>201.000 NOK/8000 hrs<br><br>96.000 NOK/yr | 1.557.000 NOK/yr<br><br>ROI =1,7 yr |

## ->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 condensers

## ->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 preferred NH <sub>3</sub> as natural refrigerant since long time and fully relied on the capability Therma Industri for the heat pump technology.                     |
| Safety problems, legislative 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.                           |

## ACTION PLAN

| IDEAS OF CONCRETE ACTIONS TO GET NATURAL REFRIGERANTS SOLUTIONS FOR 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 ?                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                             |
| <p>2.1. what kind of actions needed to expand NR systems, for :</p> <p>Technology,<br/>Training,<br/>Safety,</p> <p>Policy,<br/>Standards,<br/>Regulation,</p> <p>Market,<br/>Costs,<br/>End-users.</p> | <p>Unlimited development ongoing.<br/>With each new product/system necessary trainings are also made available.<br/>Suppliers of refrigeration accessories (EN378 qualified) should make more products available for high pressure/big size duty.<br/>Mayekawa still have too often to rely on expensive accessories designed for oil and gas industry.</p> |

# 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 COMMISSIONING WITH OPTIMAL FINE TUNING, FROM COOPERATION BETWEEN ALL PARTIES INVOLVED :

MANUFACTURER : MAYEKAWA JAPAN/ MAYEKAWA EUROPE  
CONTRACTOR : THERMA INDUSTRI  
PLANT RESPONSABLE/OPERATORS.



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# THANKS FOR YOUR ATTENTION !

& much appreciated thanks to the Contractor of the fieldcases :

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