
AMERICA
ATMO
sphere

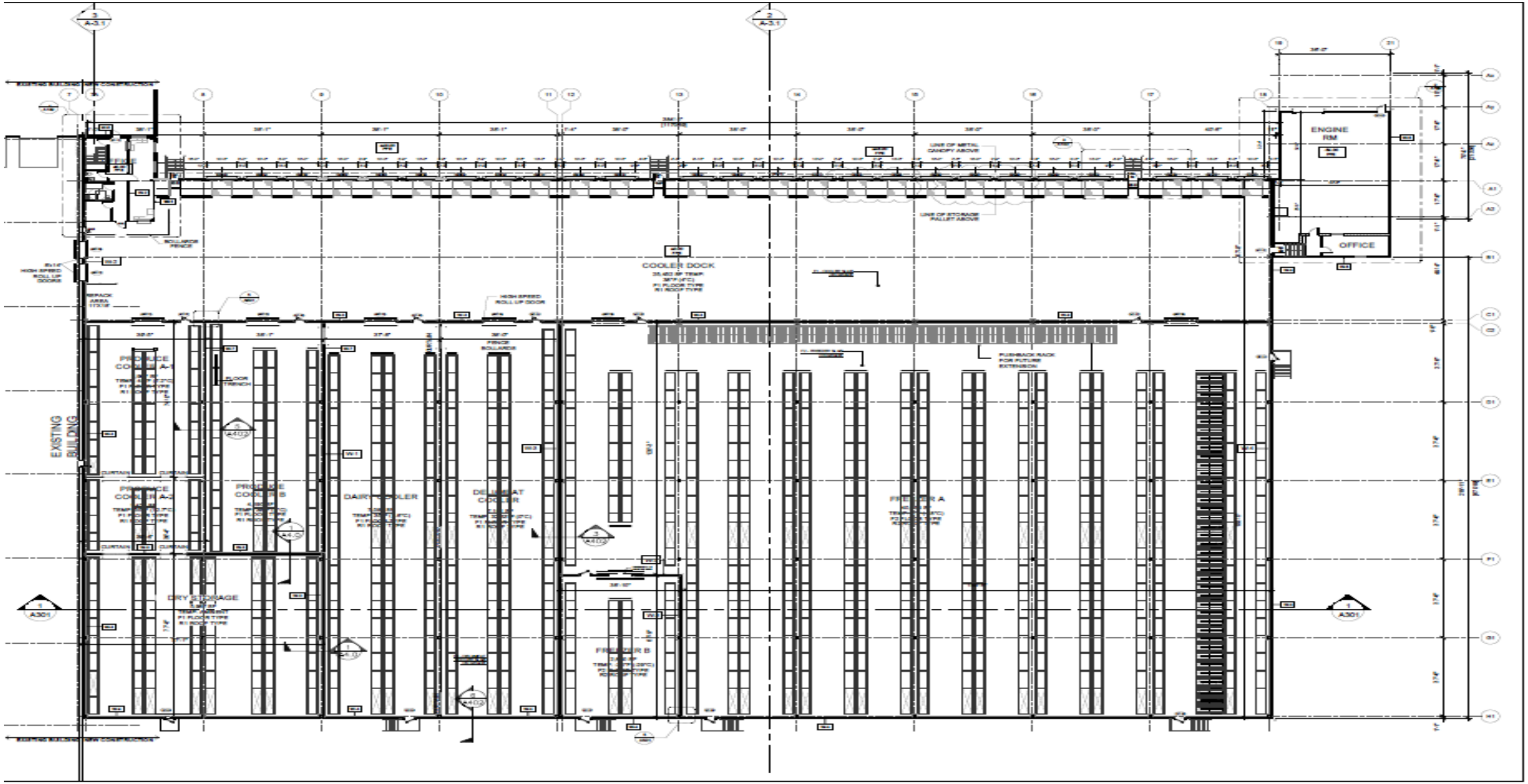
# Various Approach using Natural refrigerant For a Cold Storage Project Construction

# Introduction

- Being the leading supplier of Ammonia industrial system for more than 100 years , we are now expanding with more and more usage of $CO_2$.
- The Province of Quebec has over 7 majors Fruit and vegetables cold storage facility built and operated for more than a year
- This project will be the first one been built in Ontario
- This project will have low temperature freezer and medium temperature rooms and docks
- The customer has multiple facility using Freon, Ammonia and $CO_2$
- Proposal were made offering various alternative, from all ammonia system, ammonia/Co2 cascade and $CO_2$ transcritical


The customer is already somehow familiar with ammonia/CO2 equipment. In another facility in Ontario, the very first low charge ammonia and recirculated brine CO2 low temperature Newton System was installed for their freezer operation. It has been running for few years now with excellent results and performance

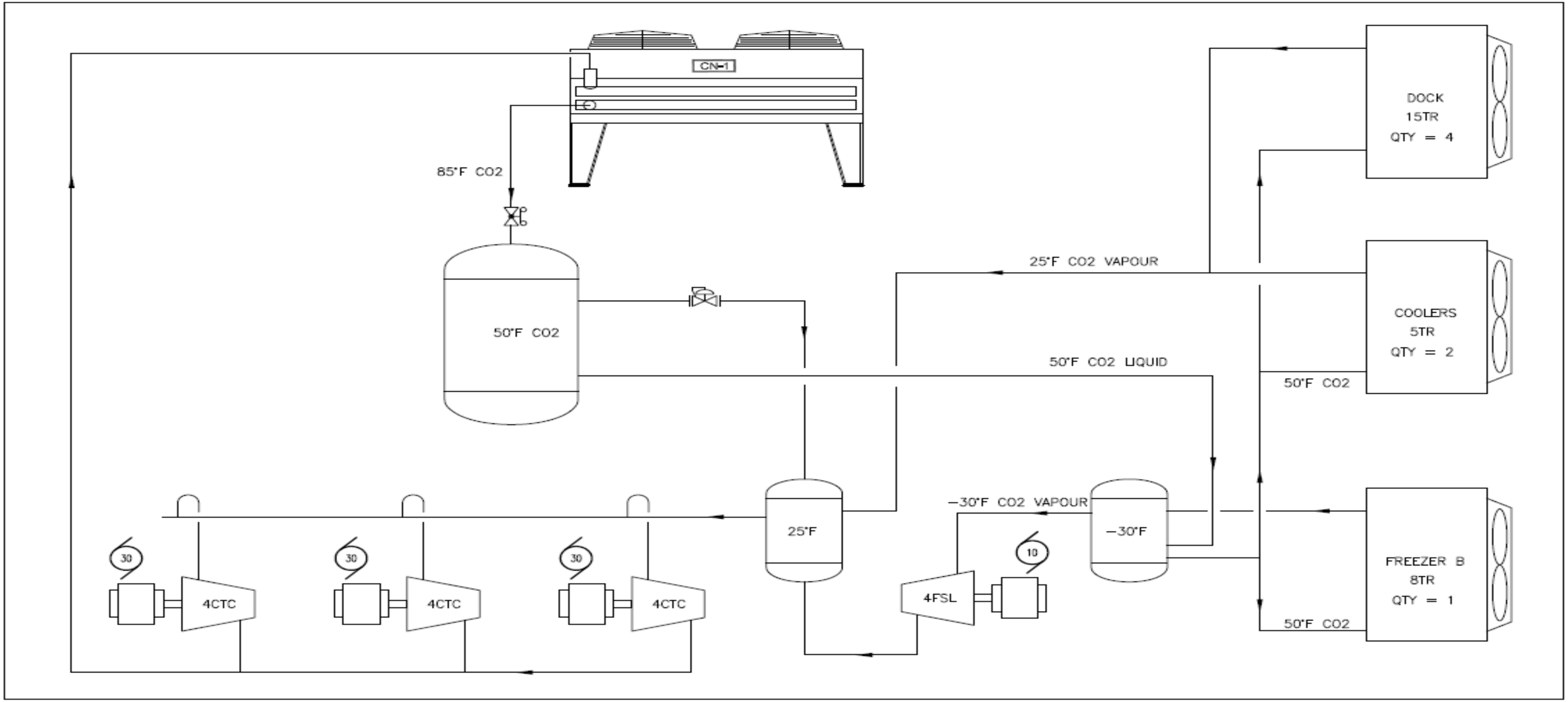
# New Building Layout



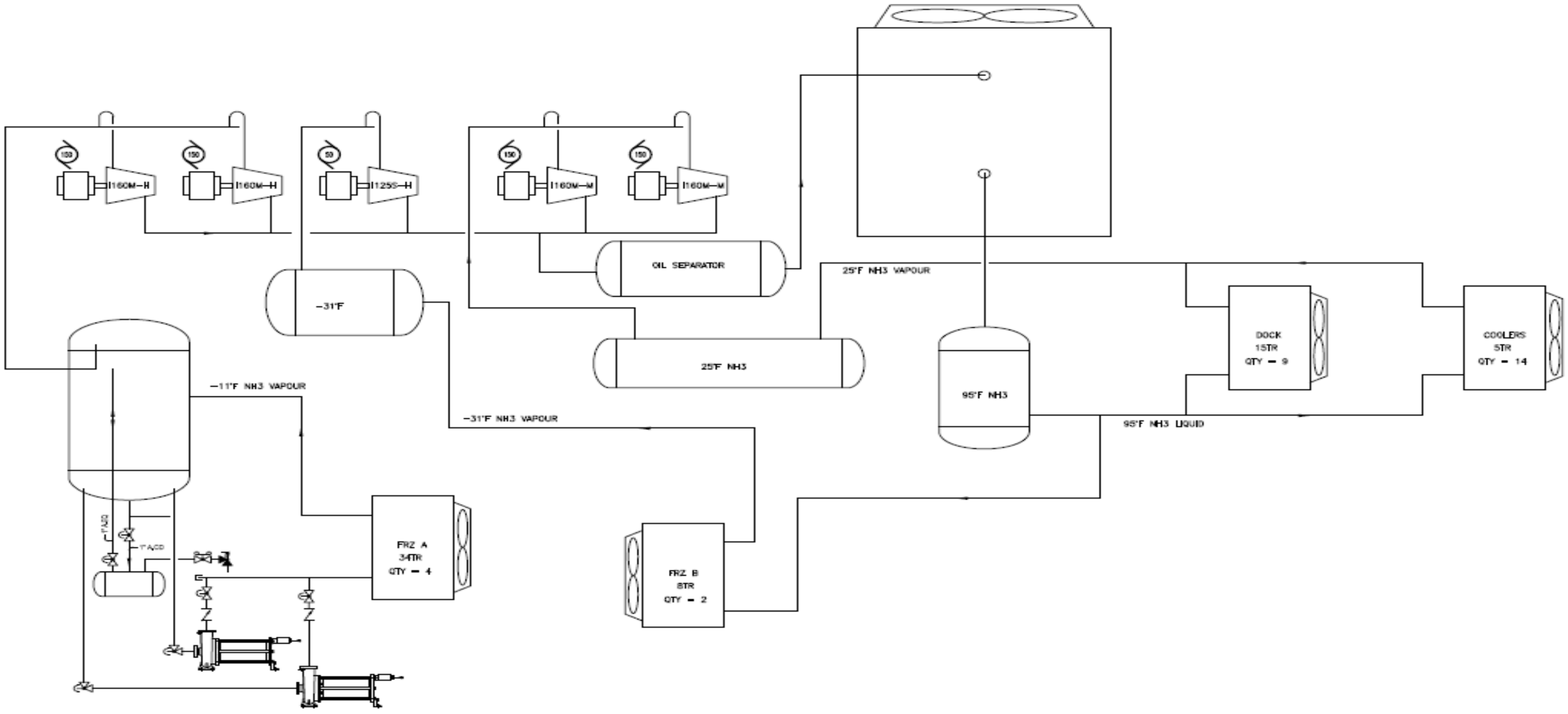
# Building Requirement

| Room Name | Clear Height to U/S of Roof Deck | Area (SF) | Temperature Range | | Relative Humidity | | |
|---|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max | |
| Dry Storage | 39'-6" | 5,885 | AMB | AMB | NA | NA | |
| Produce Cooler A-1 | 39'-6" | 2,907 | +45°F | +45°F | 0% | 65% | 10 TR |
| Produce Cooler A-2 | 39'-6" | 1,423 | +55°F | +55°F | 0% | 65% | 10 TR |
| Produce Cooler B | 39'-6" | 4,190 | +38°F | +38°F | 0% | 65% | 12 TR |
| Dairy Cooler | 39'-6" | 7,083 | +35°F | +35°F | 0% | 65% | 19 TR |
| Deli / Meat Cooler | 39'-6" | 7,161 | +32°F | +33°F | 0% | 65% | 21 TR |
| Freezer A | 39'-6" | 40,534 | 0°F | 0°F | NA | NA | 35 TR |
| Freezer B | 39'-6" | 2,630 | -20°F | -20°F | NA | NA | 15 TR |
| Cooler Dock | 28'-0" | 25,452 | +38°F | +38°F | 0% | 65% | 135 TR |
| Engine Room | 18'-8" | 2,660 | AMB | AMB | NA | NA | |
| Offices (Main Floor + 2nd Floor) | 28'-0" | 1,968 | AMB | AMB | NA | NA | |

# CO2 Transcritical System

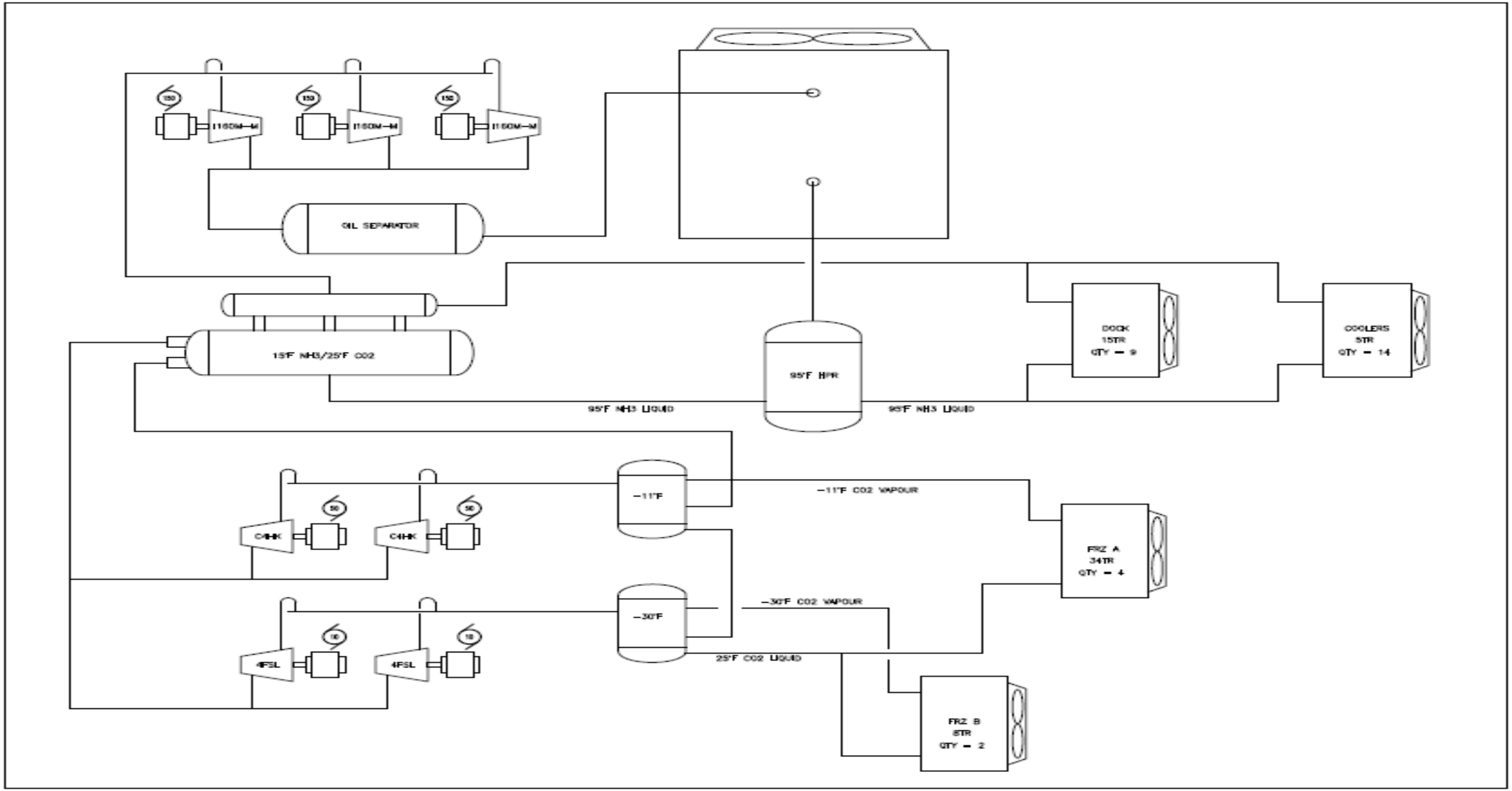


# All Ammonia

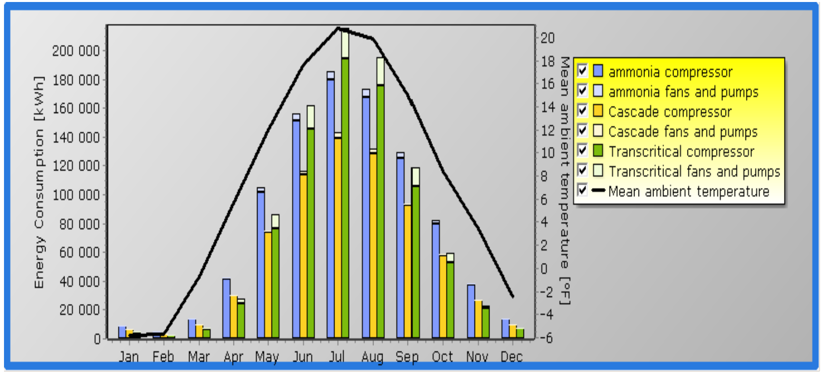


I160M–H
I160M–H
I125S–H
I160M–M
I160M–M
OIL SEPARATOR
–31°F
25°F NH3 VAPOUR
25°F NH3
95°F NH3
DOCK
15TR
QTY = 9
COOLERS
5TR
QTY = 14
–11°F NH3 VAPOUR
–31°F NH3 VAPOUR
95°F NH3 LIQUID
FRZ A
34TR
QTY = 4
FRZ B
8TR
QTY = 2

# Ammonia/CO2 Cascade



# Energy usage




**Energy consumption table**

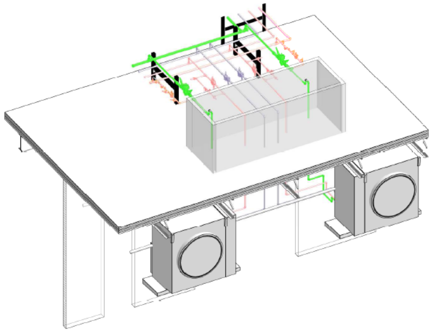
| | ammonia | | | Cascade | | | Transcritical | | |
|---|---|---|---|---|---|---|---|---|---|
| Month | Compressor [kWh] | Fans and Pumps [kWh] | Total [kWh] | Compressor [kWh] | Fans and Pumps [kWh] | Total [kWh] | Compressor [kWh] | Fans and Pumps [kWh] | Total [kWh] |
| January | 8 568,5 | 79,0 | 8 647,5 | 6 135,0 | 2,8 | 6 137,7 | 4 274,2 | 225,3 | 4 499,4 |
| February | 4 699,9 | 31,0 | 4 730,9 | 3 362,8 | 1,4 | 3 364,2 | 2 340,3 | 52,8 | 2 393,0 |
| March | 13 536,5 | 123,0 | 13 659,5 | 9 708,2 | 4,5 | 9 712,8 | 6 872,2 | 440,4 | 7 312,6 |
| April | 41 130,4 | 917,8 | 42 048,1 | 29 740,9 | 37,0 | 29 777,9 | 24 653,2 | 3 192,7 | 27 845,9 |
| May | 101 427,6 | 3 183,0 | 104 610,6 | 74 226,4 | 422,6 | 74 649,0 | 76 289,5 | 9 791,1 | 86 080,7 |
| June | 151 036,4 | 4 859,5 | 155 895,9 | 113 802,5 | 2 470,7 | 116 273,1 | 145 089,2 | 16 893,6 | 161 982,8 |
| July | 179 801,0 | 5 864,2 | 185 665,2 | 138 816,5 | 3 894,2 | 142 710,7 | 194 392,9 | 20 970,9 | 215 363,8 |
| August | 167 420,5 | 5 536,4 | 172 957,0 | 128 509,2 | 3 047,3 | 131 556,5 | 175 356,1 | 20 017,7 | 195 373,8 |
| September | 124 946,0 | 4 119,0 | 129 065,0 | 92 605,7 | 1 117,5 | 93 723,2 | 105 501,6 | 12 961,7 | 118 463,3 |
| October | 79 395,7 | 2 460,2 | 81 855,9 | 57 971,0 | 187,5 | 58 158,5 | 52 737,4 | 6 706,8 | 59 444,2 |
| November | 37 495,0 | 905,1 | 38 400,1 | 27 060,4 | 23,4 | 27 083,8 | 20 805,7 | 2 169,8 | 22 975,6 |
| December | 13 777,8 | 117,8 | 13 895,7 | 9 873,3 | 5,4 | 9 878,6 | 7 127,3 | 560,4 | 7 687,8 |
| Total | 923 235,2 | 28 196,0 | 951 431,3 | 691 811,9 | 11 214,2 | 703 026,1 | 815 439,7 | 93 983,3 | 909 423,0 |
| Average | 76 936,3 | 2 349,7 | 79 285,9 | 57 651,0 | 934,5 | 58 585,5 | 67 953,3 | 7 831,9 | 75 785,2 |

# Maintenance and Replacement

## Preventive Maintenance

We put in this category, the initial start-up, expected monthly visit and day to day good engineering practices.

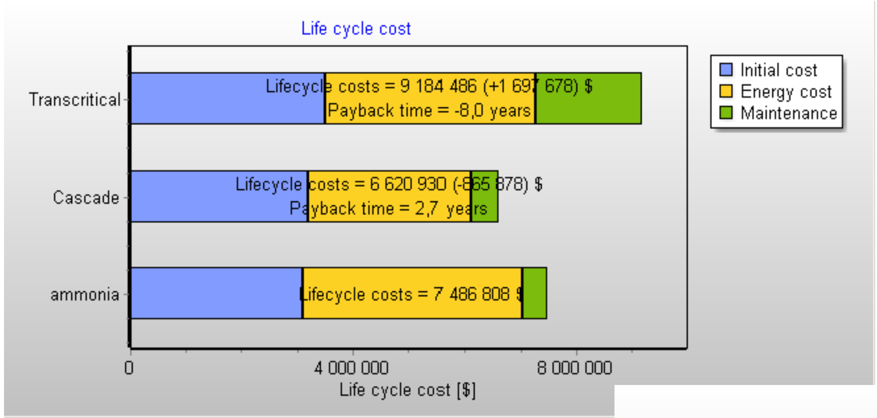
| | Ammonia | Cascade CO2/Ammonia | Transcritical |
|---|---|---|---|
| Start-up time and difficulties | $ 5200 | $ 7 800 | $ 18 200 |
| Leak test and check | By operator | By operator | $ 5000 |
| Oil drainage | By operator | By operator | |
| Relief line check up | By operator | By operator | $ 3500 |
| Set up and control adjustment | By operator | By operator | $ 5000 |
| Restart after power failure | By operator | By operator | $ 1500 |
| Piston compressor rebuilt | | 20 K x 10 Y = $2000 | In the replacement section |
| Total per year based on 30 years | $ 175 | $ 2 260 | $ 17 606 |

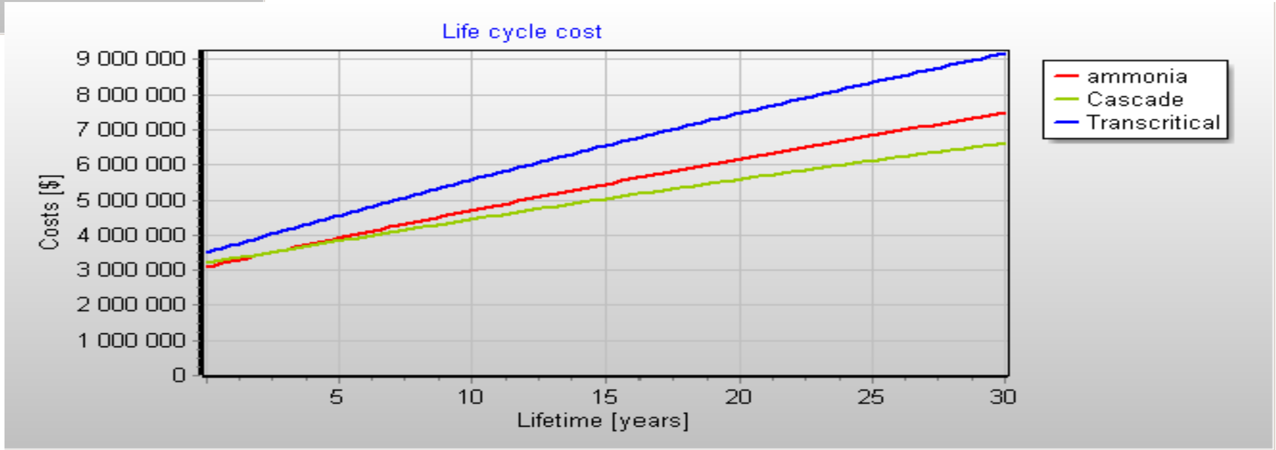


## Equipment Replacement

| | Ammonia | | | Cascade CO2/ammonia | | | Transcritical | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cost | Life Ex. | C.P.Y. | Cost | Life Ex. | C.P.Y | Cost | Life Ex. | C.P.Y. |
| Compressor | $12,000 x 5 | 30Y. | $2 000 | $12,000 x 5 | 30 Y. | $2,000 | $6000 x 19 | 5 Y. | $23,800 |
| Condenser | $106,000 | 20 Y. | $5,300 | $ 100,000 | 20 Y. | $5,000 | $18000 x 7 | 15 Y. | $8 400 |
| Condenser Motor | $1500 | 5 Y. | $300 | $1500 | 5 Y | $300 | $500 x 28 | 5 Y. | $2 800 |
| Evaporator Fan and motors | $400 x 48 | 5 Y. | $3 840 | $400 x 48 | 5 Y. | $3 840 | $400 x 109 | 5 Y. | $8 720 |
| Water Pump | $2,500 | 10 Y. | $250 | $2,500 | 10 Y. | $250 | | | |
| Ammonia pump | 4500 x 2 | 10 Y | $ 900 | | | | | | |
| Heat Exchanger | | | | $50 000 | 30 Y. | $1 666 | | | |
| Electrical Panel | $115,000 | 30 Y. | $3 833 | $108 000 | 30 Y. | $3 600 | 25 k x 7 | 15 Y. | $11 666 |
| $CO_2$ Receivers | N/A | N/A | N/A | N/A | N/A | N/A | $25,000 | 30 Y. | $833 |
| Primary Refrigerant Charge | $3000 | 20 Y. | $200 | $3000 | 10 Y. | $300 | $3,000 | 10 Y. | $300 |
| Glycol Charge | $9,500 | 20 Y. | $475 | $9,500 | 20 Y. | $475 | N/A | N/A | N/A |
| Total Per Year | $17,090 | | | $17 431 | | | $56 519 | | |
| Total over 30 Years | $446 849 | | | $509 638 | | | $1 918 487 | | |

# Life Cycle Cost



# Life Cycle Cost

| | ammonia | Cascade | Transcritical |
|---|---|---|---|
| Initial cost: | | | |
| Cost of equipment [$] | 1 400 000 | 1 550 000 | 1 650 000 |
| Cost of installation [$] | 1 400 000 | 1 550 000 | 1 650 000 |
| Annual operating cost: | | | |
| Energy consumption [kWh] | 939707,30 | 681503,89 (-258 203) | 805304,44 (-134 403) |
| Cost of maintenance [$] | 17 265 | 19 691 | 60 000 |
| Result: | | | |
| Effective interest rate [%] | 0,98 | 0,98 | 0,98 |
| Internal rate of return [%] | - | 12,59 | -100,00 |
| Total annual cost [$] | 167 618 | 128 732 (-38 887) | 188 849 (+21 231) |
| Payback time [years] | - | 7,7 | -23,6 |
| Total initial cost [$] | 2 800 000 (39%) | 3 100 000 (48%) | 3 300 000 (40%) |
| Present value of maintenance cost [$] | 446 849 (6%) | 509 638 (8%) | 1 552 907 (19%) |
| Present value of energy cost [$] | 3 891 409 (55%) | 2 822 166 (44%) | 3 334 835 (41%) |
| Life cycle cost [$] | 7 138 258 | 6 431 804 (-706 453) | 8 187 742 (+1 049 484) |

# Cost Analysis

In every cases , Strictly considering the Initial Cost only could be a dangerous trap

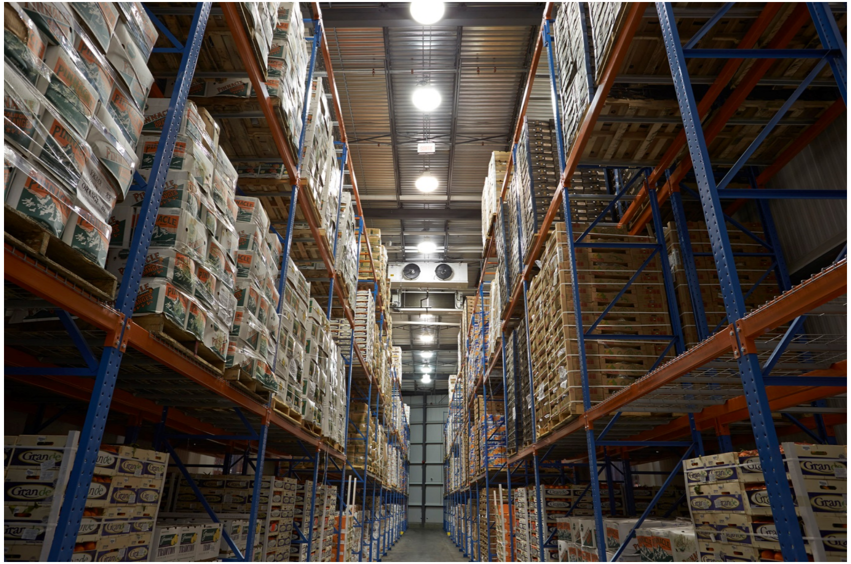
- The right Solution could be different depending on the customer criteria and priorities
- In this case the ammonia/Co2 cascade system had the lowest Total Cost of Ownership
- The price of energy in Ontario is calculated at 0,16 $/kwhr and this reality makes the energy portion of the total cost more impactful than the other components.
- The maintenance and replacement cost component had a bigger value for the transcritical system considering the more commercial equipment type, commercial components and the number of compressors necessary
- Considering the possible of using multiple transcritical rack might had avoided the requirement of an operator, then the TCO would have been slightly better for the transcritical proposal.

## Barriers and Solutions

- Using new technology is always a challenge
- Customer are face with numerous element composing their possible solution and need to be capable of evaluating all of those
- Investment should be made on Total cost of Ownership
- Operator requirement in the Province of Ontario is a challenge and has a tremendous impact on type of system.
- Government and regulation authorities are not yet ready for some NR usage like $CO_2$.
- Some customers capable of understanding the impact of TCO while most of others have limited knowledge and are being the hostage of some consultant and contractors still promoting lower initial cost Freon system.

# Lessons learnt

- Changes is inevitable
- The pace of that changed is different depending on rules and obligations
- It is difficult to have establish behavior changed, going this route is the future



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Thank you very much!