"Freon" Rooftop Units v. Central Industrial Refrigeration Systems

Over the years there have been numerous papers written about the comparison of "freon" commercial systems to ammonia industrial refrigeration systems, all of which verify the cost efficiency of the industrial central systems. The following is condensed from them.

The chemical properties of "freon" v. ammonia and CO_2

- The thermodynamic chemical properties of the "freon" does not permit it to be as efficient as ammonia or CO_2.
- The compressor sizes (displacement) to do the same amount of work (refrigeration) for CO_2 compressors are 1/10 the size of that required for "freon," which means far less maintenance and better efficiency.
- The latent heat of vaporization is also much higher to ammonia and CO_2, which means pipe can be smaller, with less pressure drop, and less refrigerant is required.
- Because oil mixes with "freon" refrigerant, it decreases heat transfer efficiency and tends to separate and hole up in the evaporators in low temperature applications.

Regulations on "freon" because of the environmental impact to the ozone layer

- The use of all "freons" is closely monitored. Sara Lee was fined $5,000,000 a few years ago for not keeping good records on the loss and usage for their "freon" systems.

- The cost and the manufacture of "freon" in the US will be stopped, and we will ultimately be buying it from China.
- Regulations are tougher on "freon" than on ammonia systems when the ammonia charge is less than 10,000 pounds, and CO_2 does not require regulation as a refrigerant.

Safety and usage

- It is a well-known fact that "freon" systems typically lose 25% of their refrigerant charge per year, while CO_2 and ammonia would be on the order of 1% to 2% loss.
- More people die from asphyxiation from "freon" than ammonia or CO_2. Ammonia is self-alarming. Under heat, "freons" can break down into phosgene gas, which has been known to kill people when smoking cigarettes in the presence of "freon."

Design efficiency

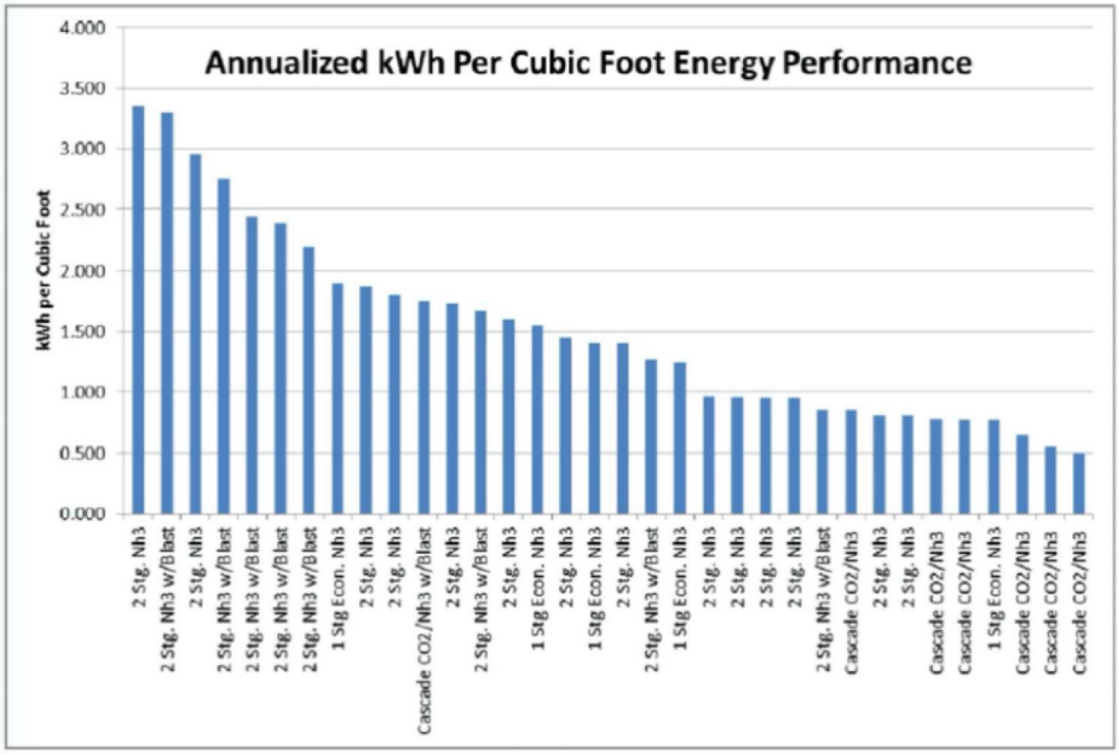
- The number of compressors used in a refrigeration system can determine how efficiently a given refrigeration system can operate. Refrigeration loads can vary from day to day, and weekly, winter and summer. Cooler and dock loads can vary from 100% to 0%. Freezers will generally vary in the range of 100% to 50%. It obviously takes more than one compressor to do this, which is all that packaged "freon" systems normally have.
- The type of compressors make a tremendous difference in the system efficiency. 3,600 rpm compressors are, across the board, less efficient than 1,800 or 1,200 rpm reciprocating compressors. 3,600 rpm compressors cannot be cycled as often as 1,800 rpm compressors because the smaller windings in the 3,600 rpm motor get overheated when they are repeatedly started. Attempts to make them efficient with the addition of VFDs (variable speed drives) are counter productive. At full load the VFDs lose 8% efficiency.
- Air cooled condensers on packaged systems will make compressors use 20% to 30% more work of compression, and will cause higher oil usage and valve wear because of higher temperatures and super heat.

- Diversity of the refrigeration load is another key to why a central system is more efficient. Not all loads peak at the same time. The central system can take advantage of when some rooms are busy and others are not. Single packaged systems cannot do that. It's no different than putting individual window air conditioning units in each room of a house; a unit in one room cannot benefit another room. We have found over the years that when we combine two machinery room into one machinery room for the same facility, you will eliminate approximately 1/3 of the compressors.

Construction and maintenance cost

- Construction of a single central machinery room is far more cost effective than the construction of a dozen machinery rooms on separate structural steel platforms with enclosures of 50 to 60 feet on the roof to support all of the same equipment.
- Maintenance will become very expensive when a compressor needs to be replaced, and rental of a $10,000 crane will be necessary to replace it. The same is true for drums of oil and other supplies that would otherwise be on the floor of the machinery room at dock height.

When all is said and done, ammonia and ammonia/CO_2 systems do and can achieve efficiencies below 1 kw/cuft/year for straight freezer storage facilities, while packaged "freon" systems cannot.


Annualized kWh Per Cubic Foot Energy Performance
kWh per Cubic Foot
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
2 Stg. Nh3
2 Stg. Nh3 w/Blast
2 Stg. Nh3
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2 Stg. Nh3 w/Blast
2 Stg. Nh3 w/Blast
1 Stg Econ. Nh3
2 Stg. Nh3
2 Stg. Nh3
Cascade CO2/Nh3 w/Blast
2 Stg. Nh3
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2 Stg. Nh3
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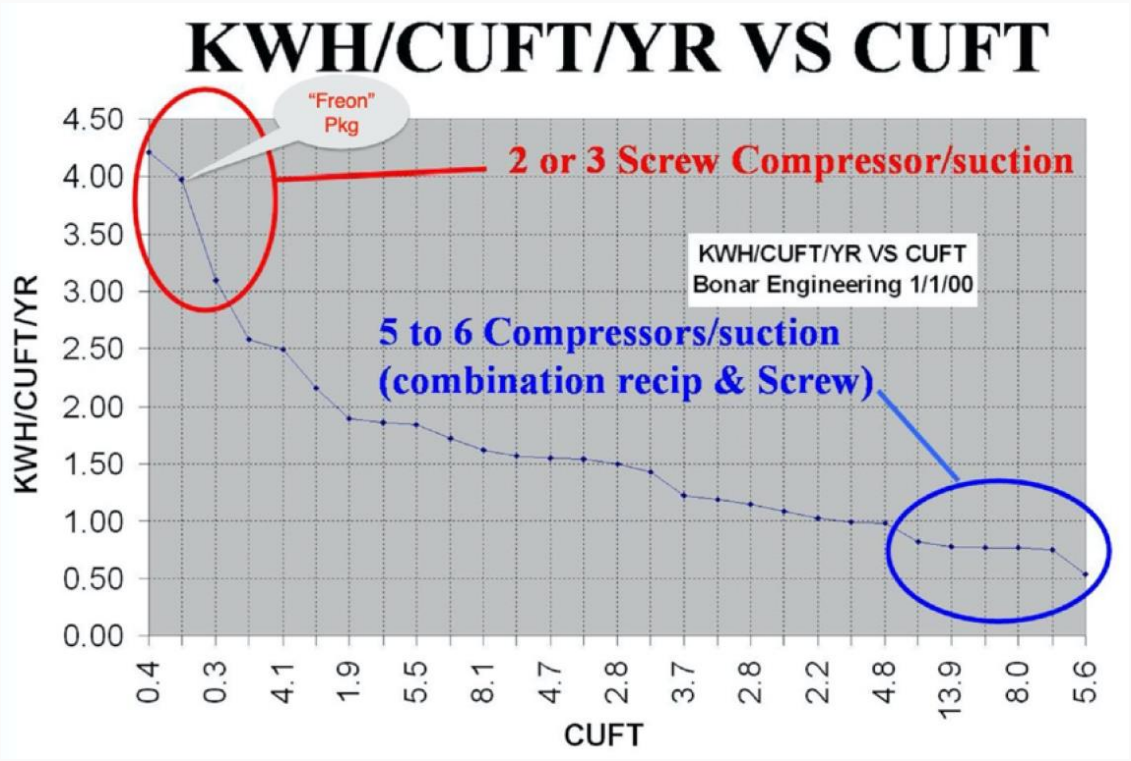
KWH/CUFT/YR VS CUFT
"Freon" Pkg
2 or 3 Screw Compressor/suction
KWH/CUFT/YR VS CUFT
Bonar Engineering 1/1/00
5 to 6 Compressors/suction
(combination recip & Screw)
KWH/CUFT/YR
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.4
0.3
4.1
1.9
5.5
8.1
4.7
2.8
3.7
2.8
2.2
4.8
13.9
8.0
5.6
CUFT