Advancements in Centrifugal Chillers Magnetic Bearing Oil-Free Technology

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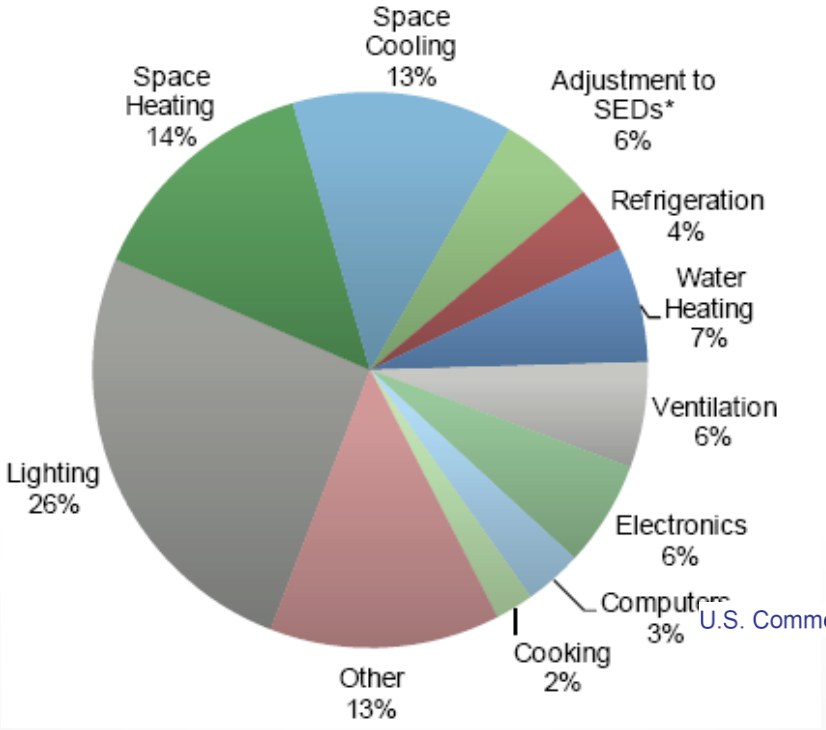
Today's Building Market Demands

- Energy cost expected to rise
- HVAC equipment accounts for over 25% of the primary energy consumed in commercial buildings in the US[1]
- Energy efficiency and reliability are key concerns

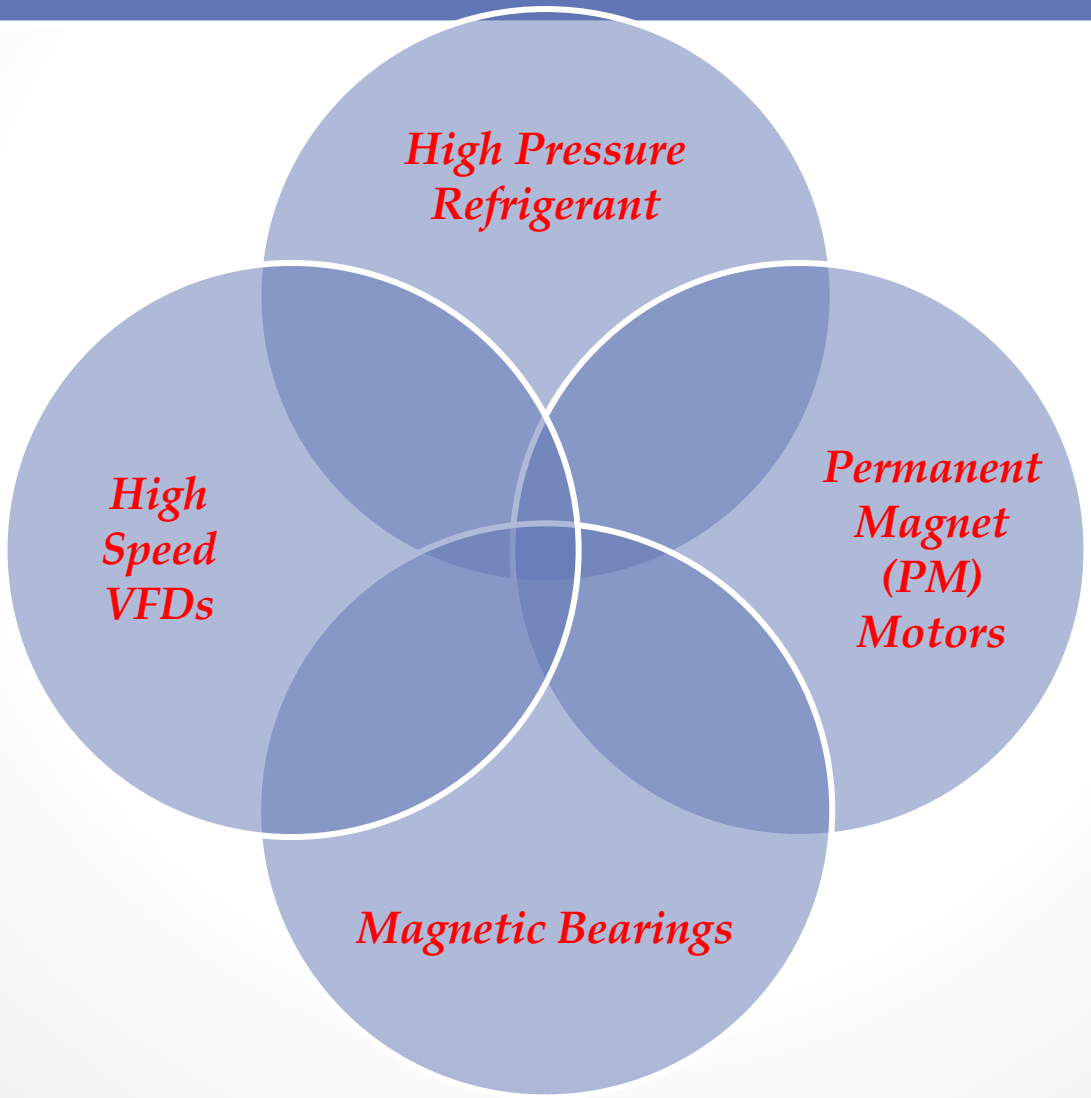


U.S. Commercial Sector Primary Energy End-Use (2005)

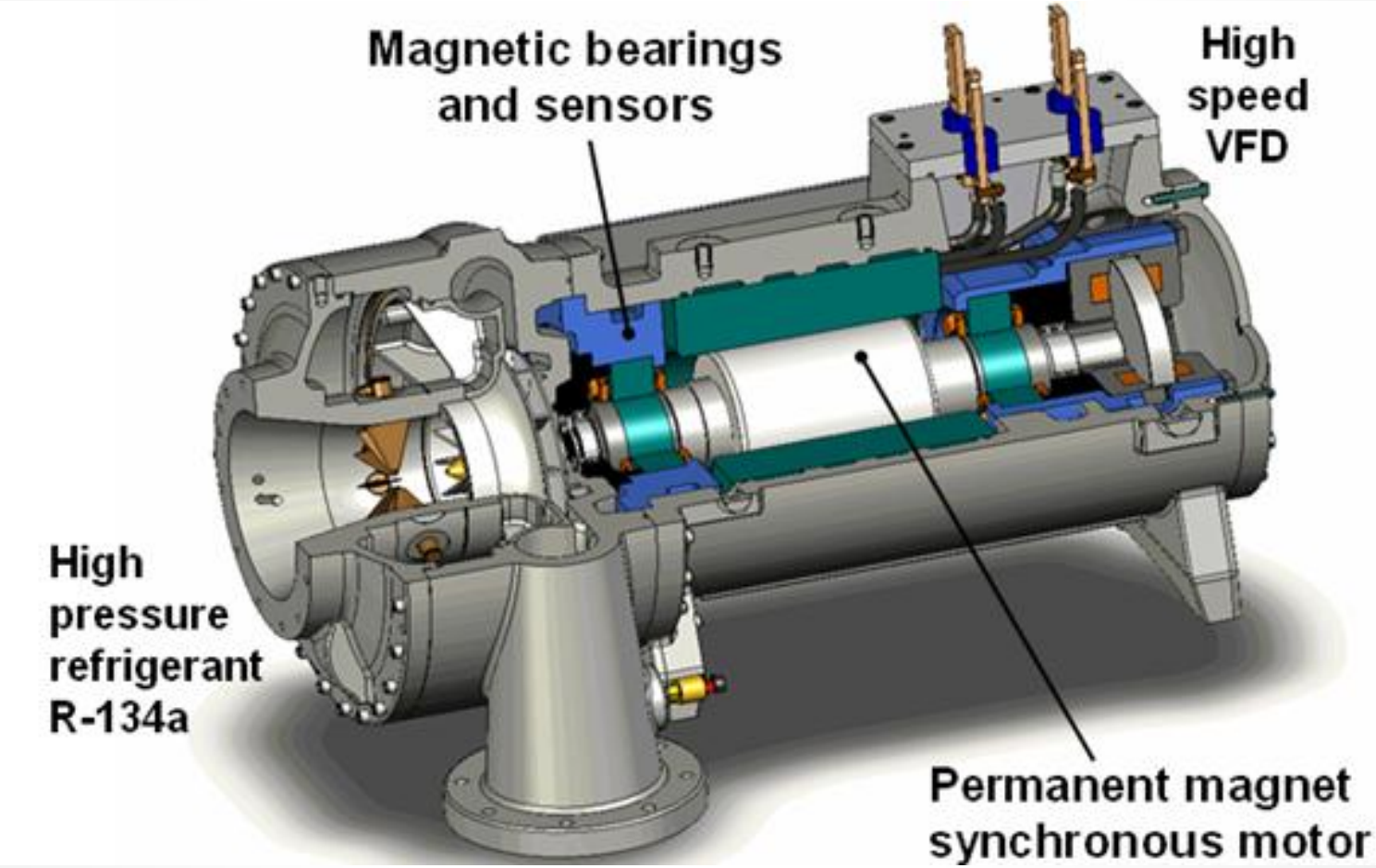
Past and Current Technologies

Water-cooled, centrifugal chillers are the most versatile class of chillers available, meeting customer needs in capacities > 100 Tons	• Best Water Cooled Chiller Efficiency
Centrifugal Chillers are the largest consumer of energy in the HVAC system	• How do you improve what is already great?
Efficiency improvements difficult within same framework of the technology	• Engineering/design improvements limited to <2% were considered significant! No room to get better…maybe

New Technology/New Standards in Efficiency

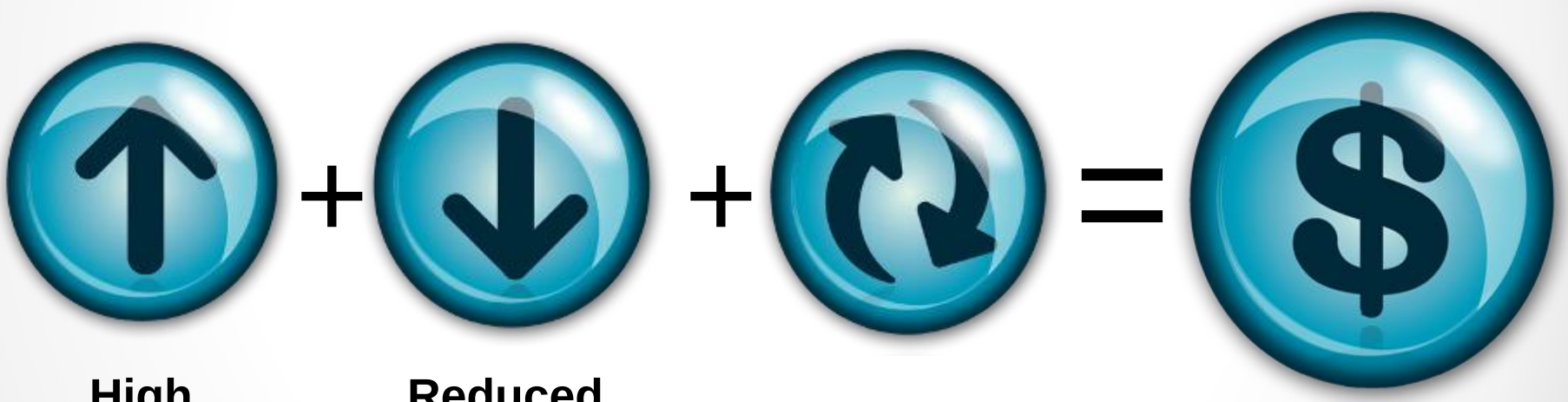


Enabling Technologies for Efficiencies



What's really important?

System Energy Efficiency and Operating Costs
Sustainability and Green



High Efficiency + **Reduced Maintenance** + **Sustainability** = **Lower Total Cost of Ownership**

How were the choices made?

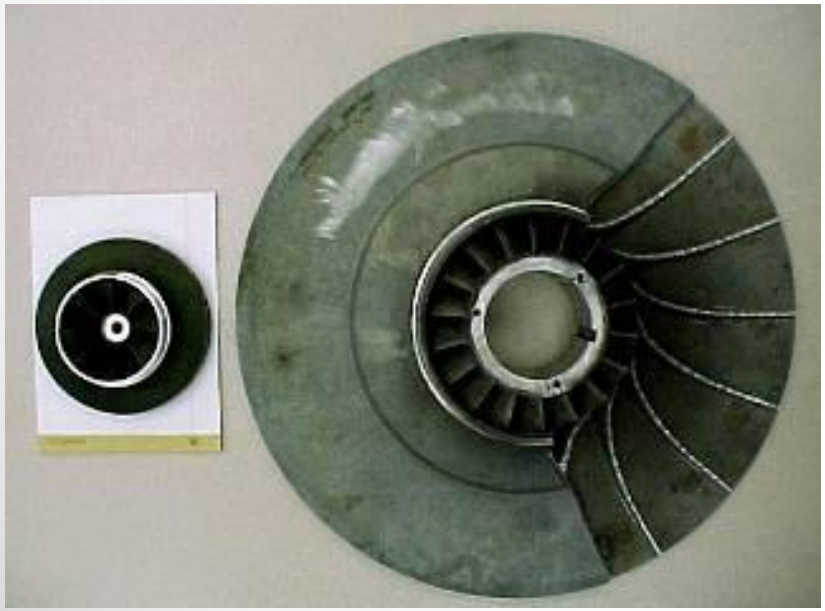
Crucial Design Choice
…the right refrigerant

Positive Pressure

Keep contaminants out

Low specific volume

Lower normalized flow rate (cfm/ton)



Refrigerant	Specific Volume, ft^3/lb	Normalized Flow Rate, CFM/ton
R-123	5.9327	18.33
R-134a	0.9528	2.86

Conditions:

40°F saturated vapor

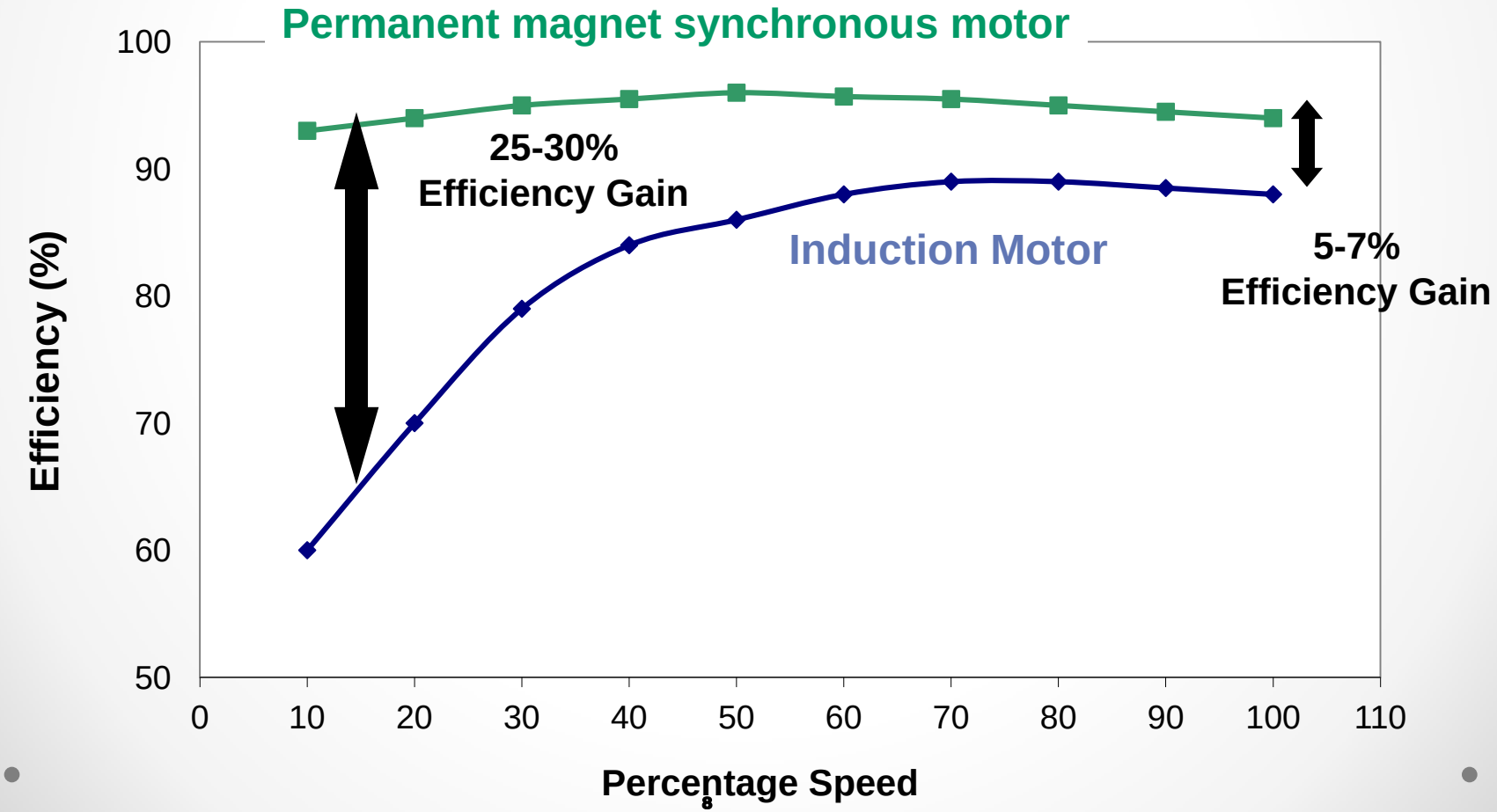
5.78 psia for R-123

49.94 psia for R-134a

100°F saturated condensing

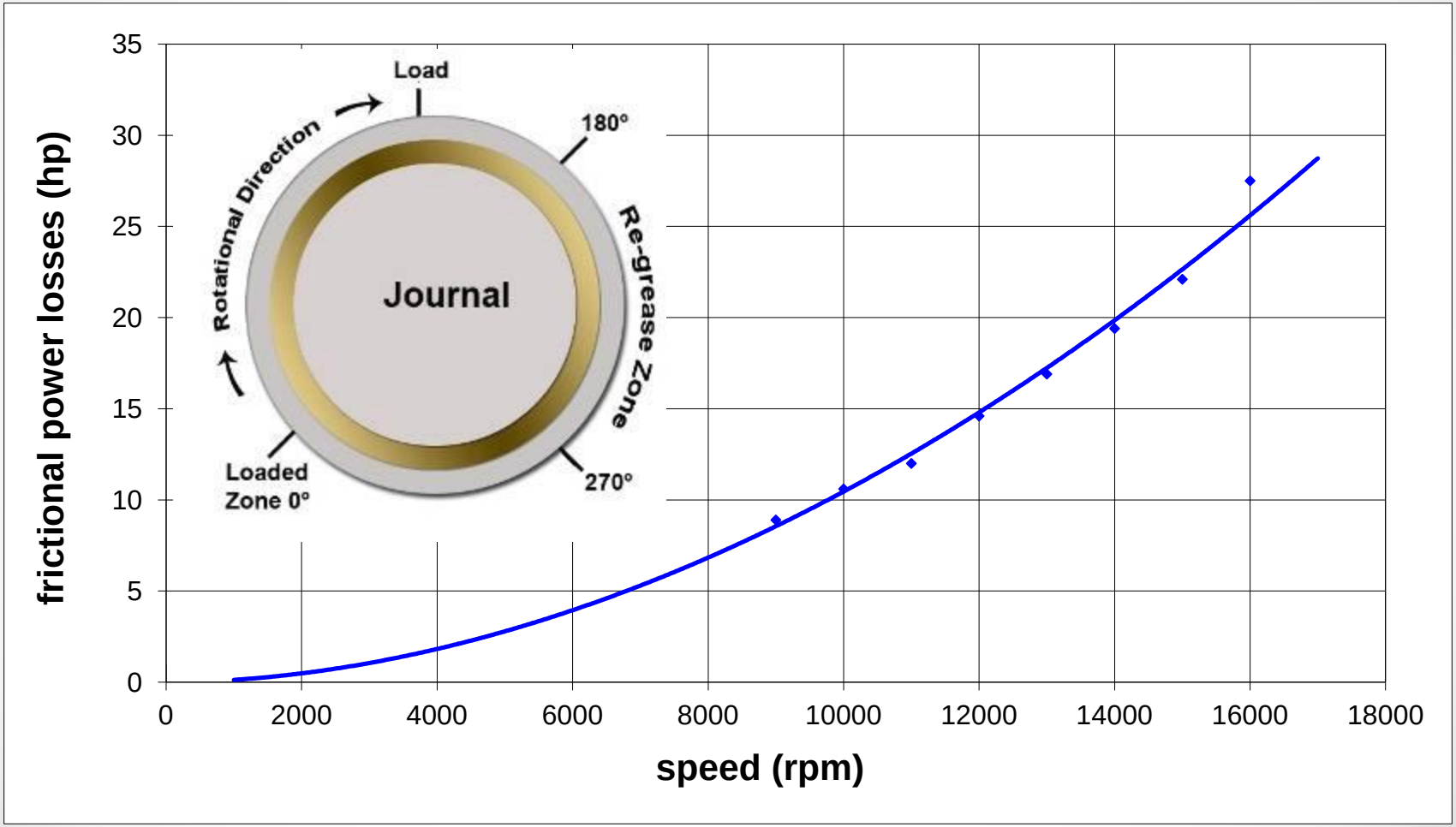
8°F subcooling and 0.5°F superheat

Crucial Design Choice ...Motor Type



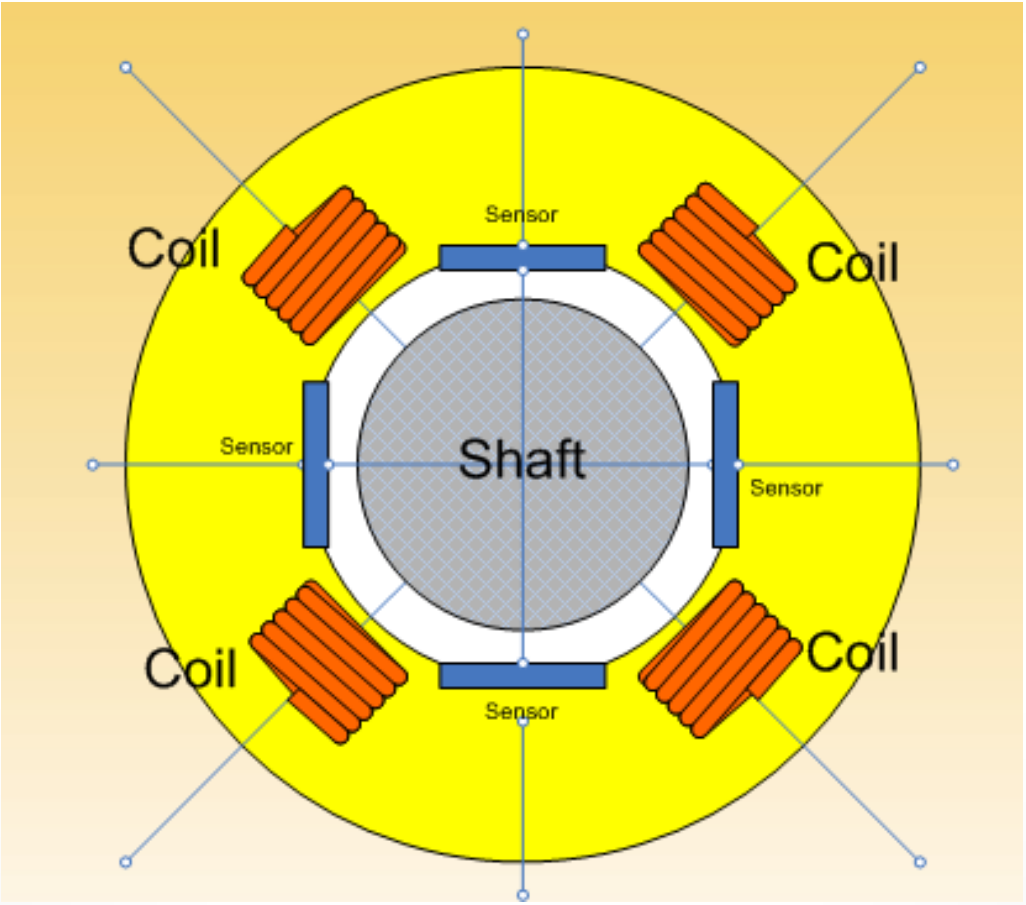
Crucial Design Choice…Bearing Type

Hydrodynamic has significant frictional power losses



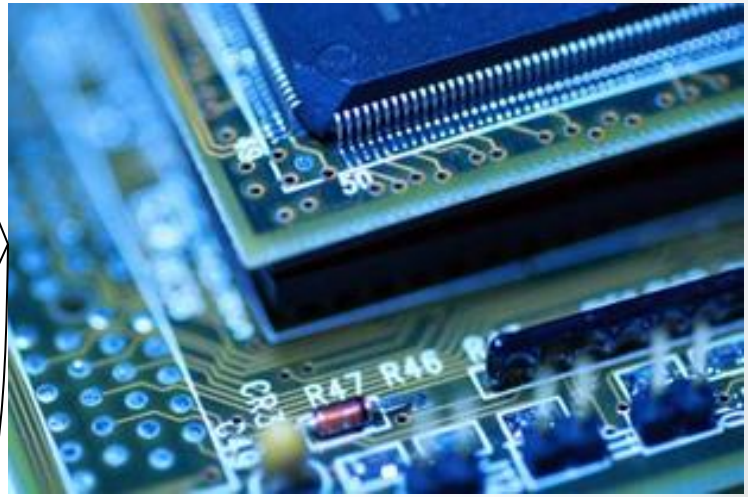
Crucial Design Choice…Bearing Type

Magnetic Bearings-very limited losses

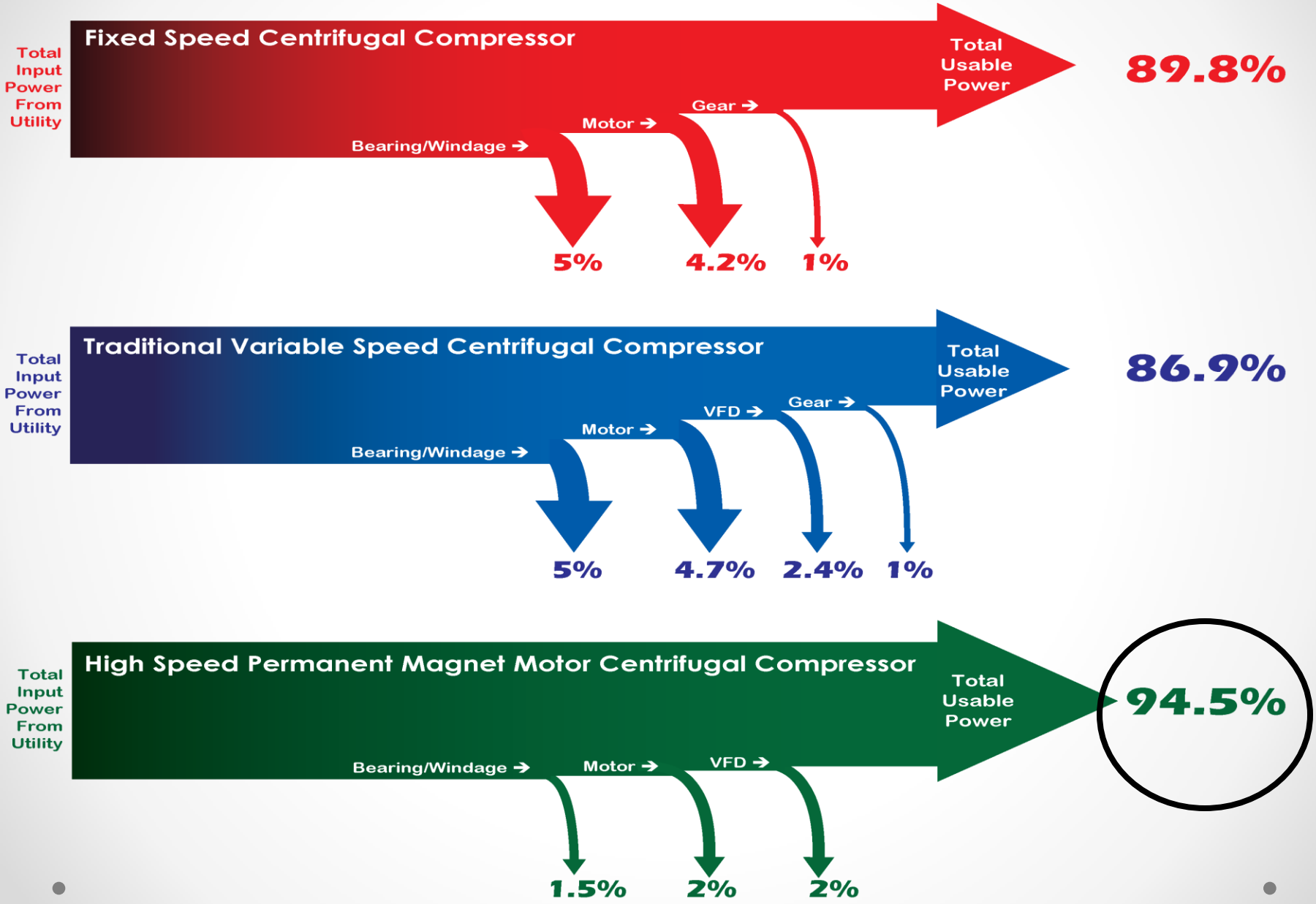


Advancements in Magnetic Bearings

High speed digital processing
Lower cost than 5-10 years ago
High reliability
Standardized design



Comparisons



Controlling the compressor speed …what works best?

$$IPLV \text{ or } NPLV = \frac{1}{\underset{A}{0.01} + \underset{B}{0.42} + \underset{C}{0.45} + \underset{D}{0.12}}$$

Full Load 1% →

***Where*:**

A = kW/ton at 100% & 85°F CEWT

B = kW/ton at 75% & 75°F CEWT

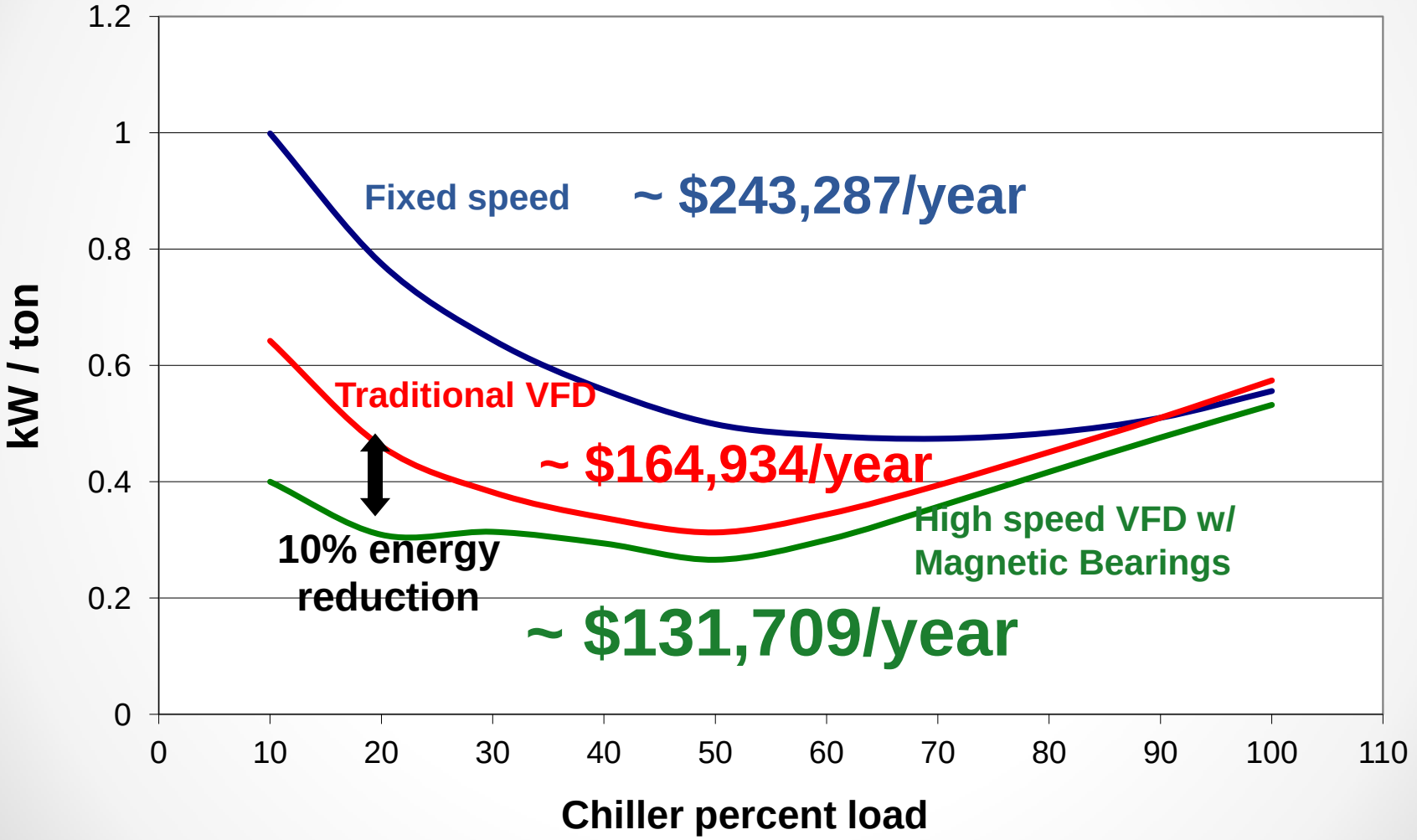
C = kW/ton at 50% & 65°F CEWT

D = kW/ton at 25% & 65°F CEWT

AHRI Standard 550/590-2003, Appendix D

Fixed Speed? Traditional VFD?

High speed VFD w/Magnetic Bearing?

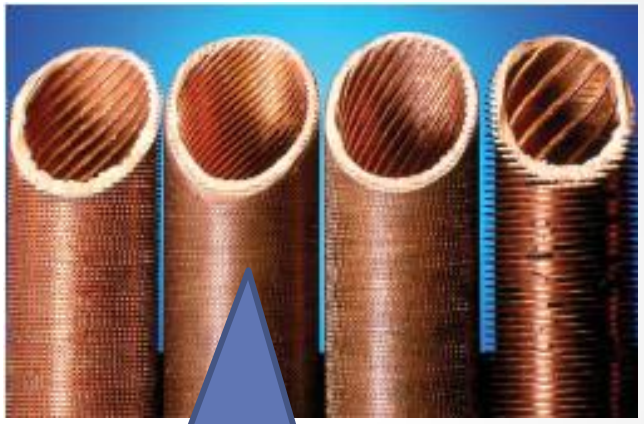


Sustainability?

From ASHRAE Research Project 751-RP,
"Experimental Determination of the Effect of Oil on Heat Transfer with Refrigerants HCFC-123 and HFC-134a",

Conclusions and Recommendations:

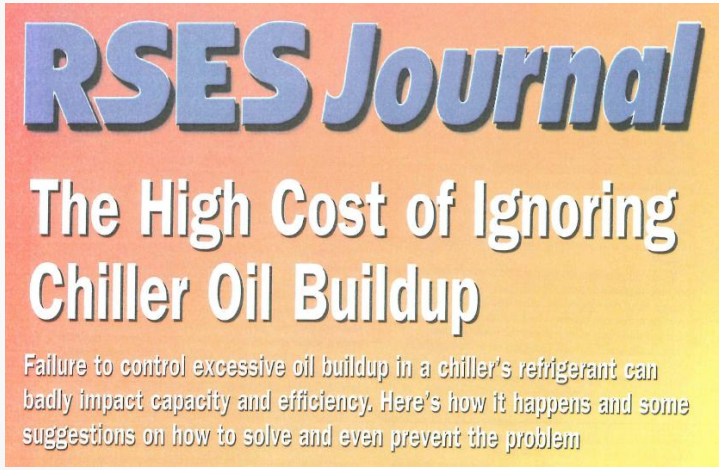
"The effect of POE oil on the heat transfer coefficient of R-134a flowing across a bundle of Turbo-B2 (HP) tubes is a reduction in heat transfer coefficient. The heat transfer ratio drops steadily with oil concentration and reaches a value of 0.65 [from 1.0 normalized] at an oil concentration of 10%."



Small grooves or dimples in the tubes create more surface area and better heat transfer. However, they also hold onto oil

Sustainability Benefits

Positive pressure, oil-free design eliminates the performance degradation due to non-condensables and oil contamination of the refrigerant

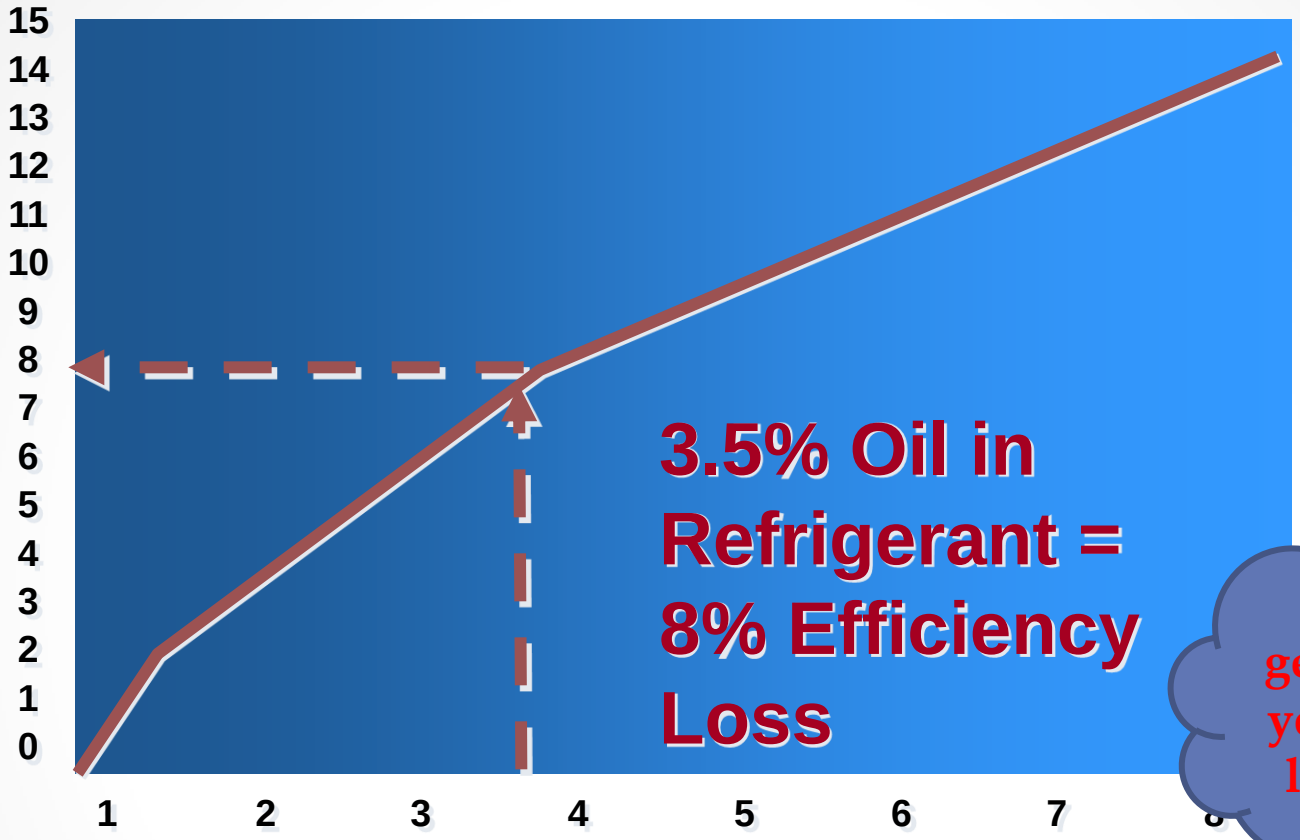


Oil Contamination

Oil In Evaporator	Performance Loss
1-2%	2-4%
3-4%	5-8%
5-6%	9-11%
7-8%	13-15%

Source: The News, 04/15/04, by Jack Sine

Oil degrading performance is counter to sustainability!



Are you getting what you paid for long term?

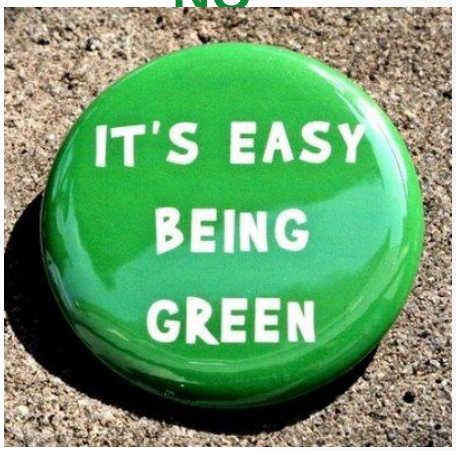
.576 kw/ton
.38 IPLV

7-12 gallons

.622 kw/ton
.410 IPLV

More Sustainability Benefits

	Traditional Centrifugal Chiller	Oil-Free Chiller
Oil	YES	NO
+ Oil Heater	YES	NO
+ Oil Cooler	YES	
+ Oil Pump/Starter	YES	
+ Oil Reservoir	YES	
+ Oil Filter	YES	
+ Oil Piping/Valving	YES	
+ Oil Sensors/Controls	YES	NO
+ Annual Oil Analysis	YES	NO
=	More things to break, more maintenance, more $	No energy losses, no concerns, no annual oil change and disposal, maintenance savings



Let's make this simple:

Oil in the chiller evaporator creates a decrease in efficiency over time as the tubes foul, lessening heat transfer. The best efficiency you can get out of an oil chiller is when it first starts up.

No oil in the chiller equates to less maintenance, less start up concerns, no other parasitic loads related to oil.

Other Advantages

- Resistant to Power Line Disturbances
  - Rides through voltage drops
  - Meets semi conductor industry standard SEMI F47

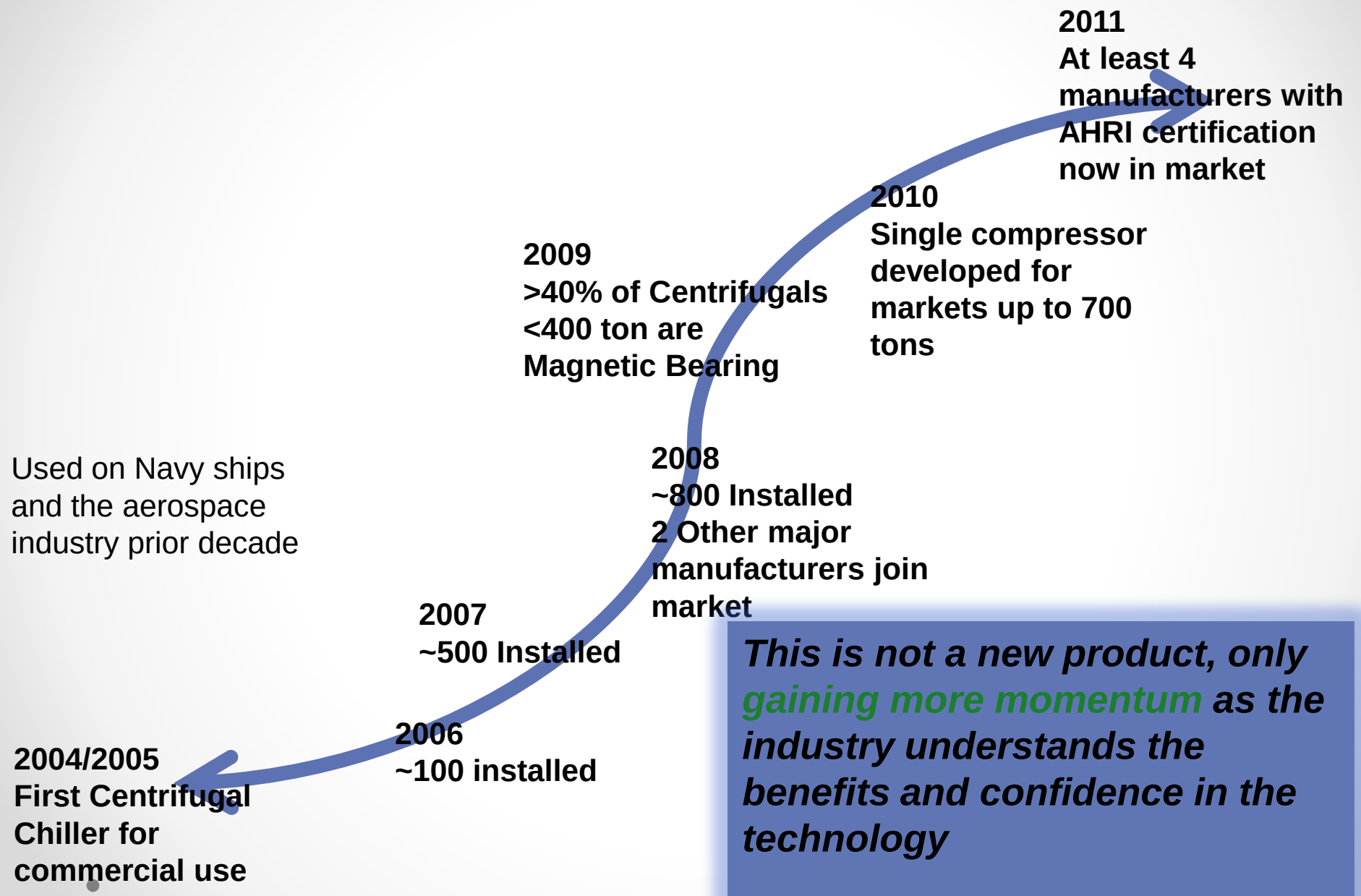
Regenerative power system keeps bearings powered until shaft stops spinning

- Rides through short duration power loss
- Extremely low inrush at Start Up

What Else?

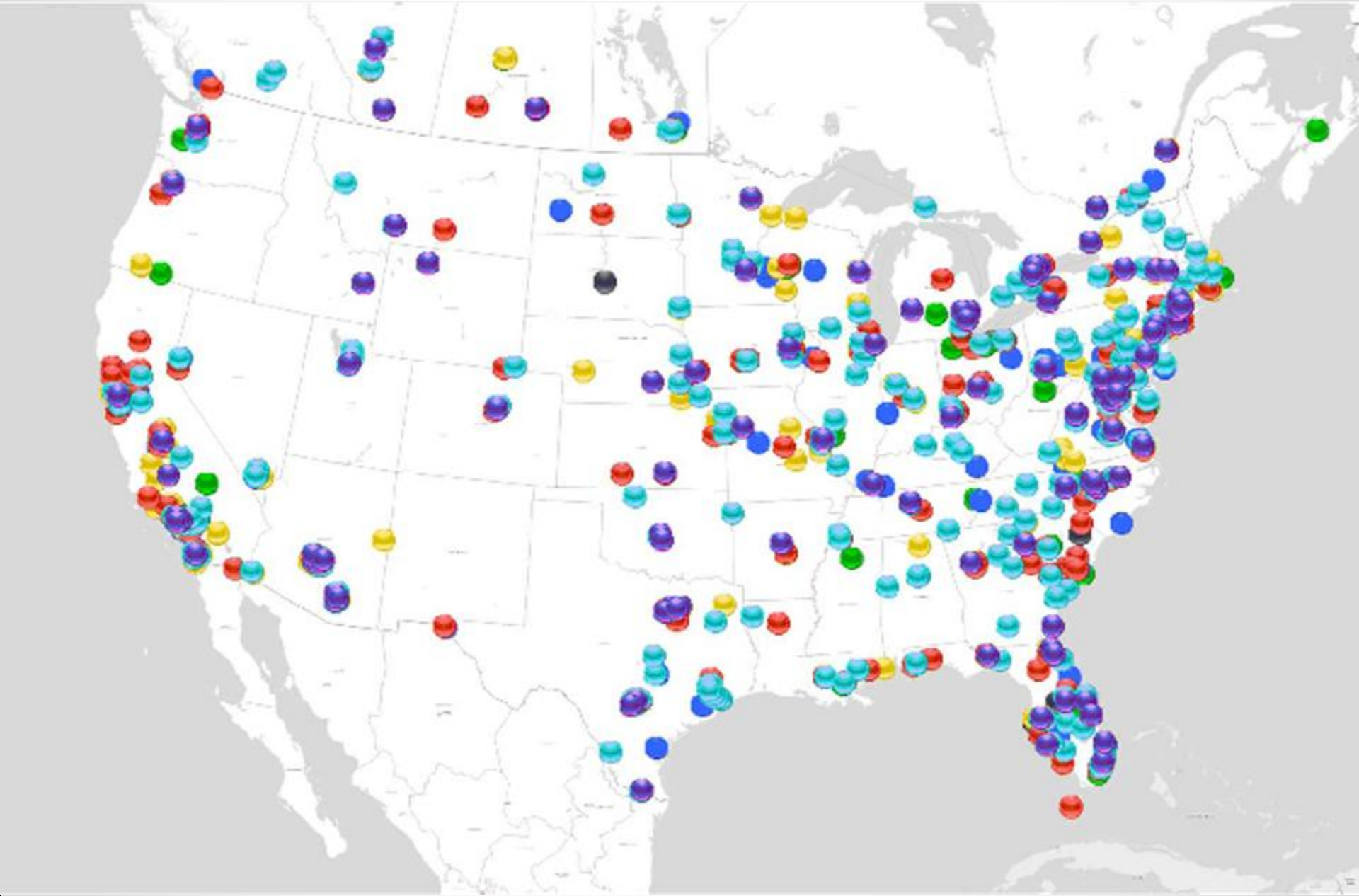
- Low Maintenance-no oil related issues
- Reliability-no friction, less wear
- Maximum equipment uptime
- Quiet operation
- Ease of installation-compact
- Ease of service
- Utilities- rebates improved for better for IPLV
  - Some even giving bonus credit for being oil-free!

Magnetic Bearing Chiller Timeline



This is not a new product, only gaining more momentum as the industry understands the benefits and confidence in the technology

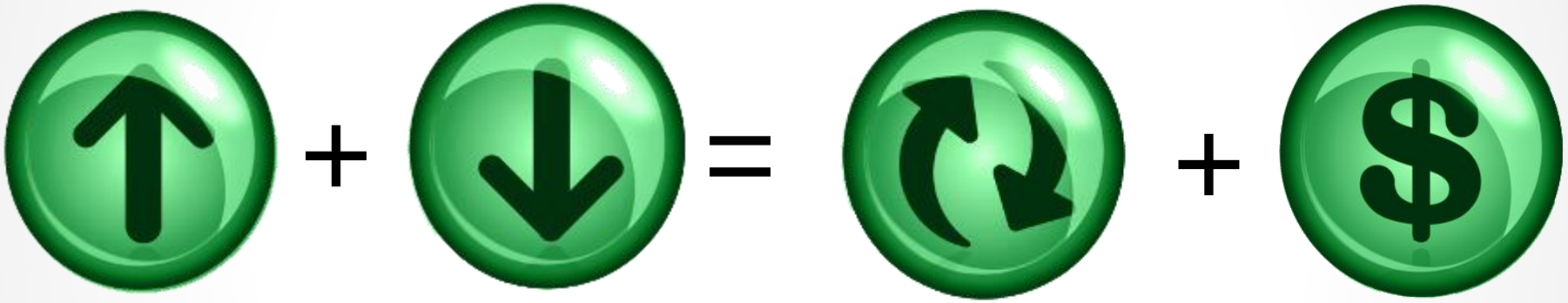
Installations



Challenges

- Higher first-cost
- Limited voltages and frequency (460V and 575V)
- New skills /concepts required for servicing
- Perception, taking the technology leap still real

What does the technology mean to owners?



High Efficiency

Reduced Maintenance (No oil, No purge)

Sustainability

Lower Total Cost of Ownership

Thank you!

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