LOW GWP CHILLER DEVELOPMENT

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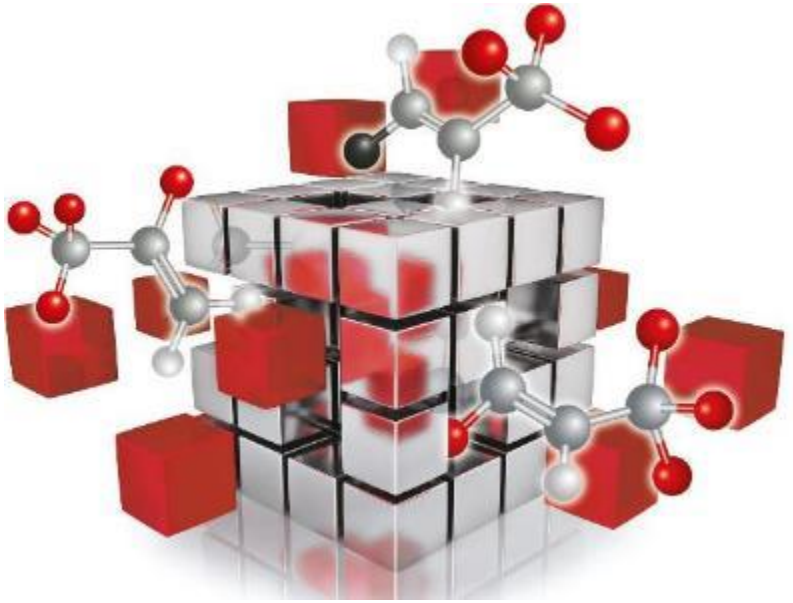
Agenda

- Introduction
- Refrigerant Roadmap
- Chiller Fluids
- Compressor Technologies
- Medium Pressure Chillers
- Low Pressure Chillers
- Conclusions



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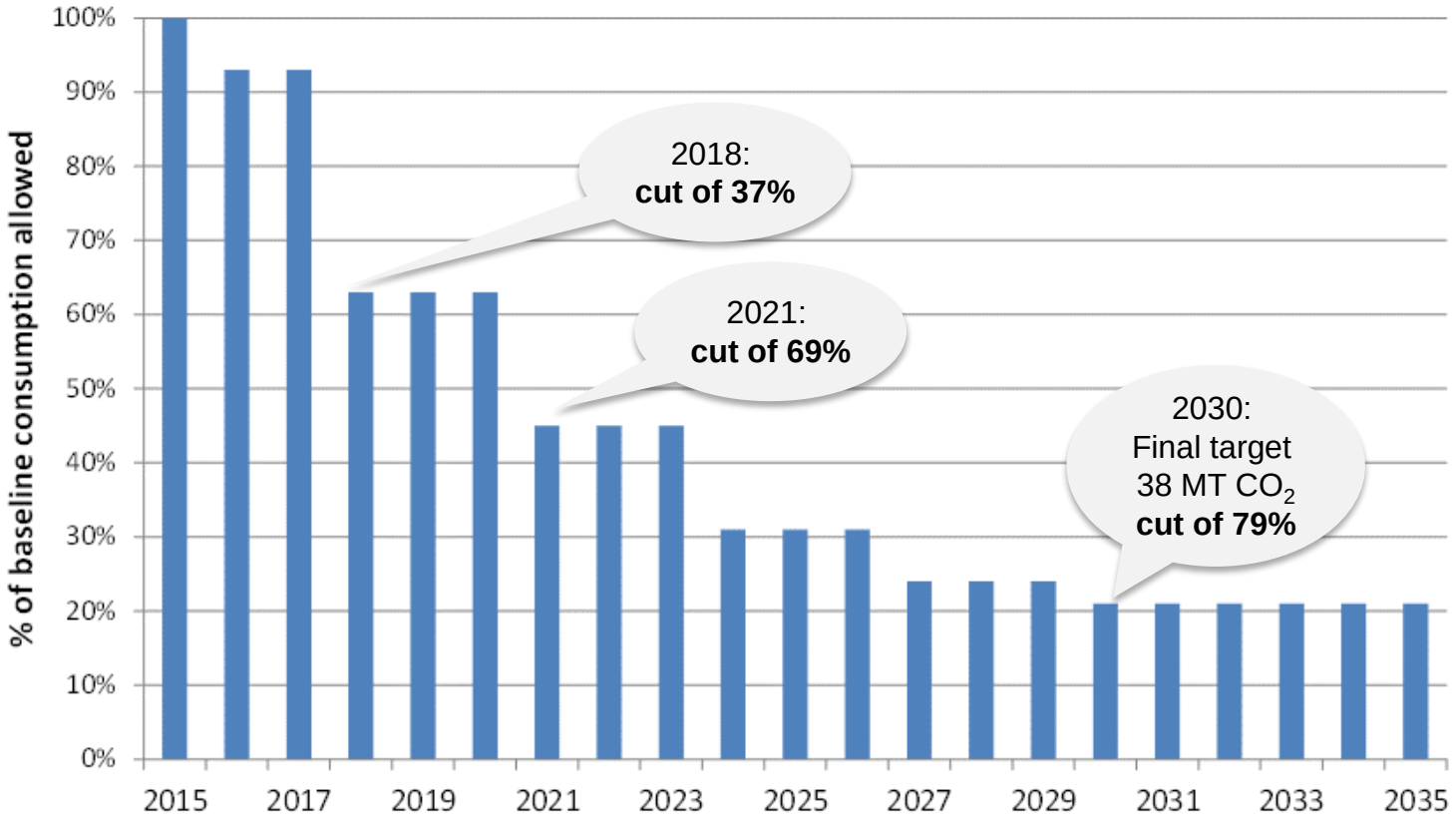
F-Gas Implications On Chillers



- Phase down controlled by a quota allocation system
- Declining supply of HFC
- Increasing refrigerant prices weighted on GWP value

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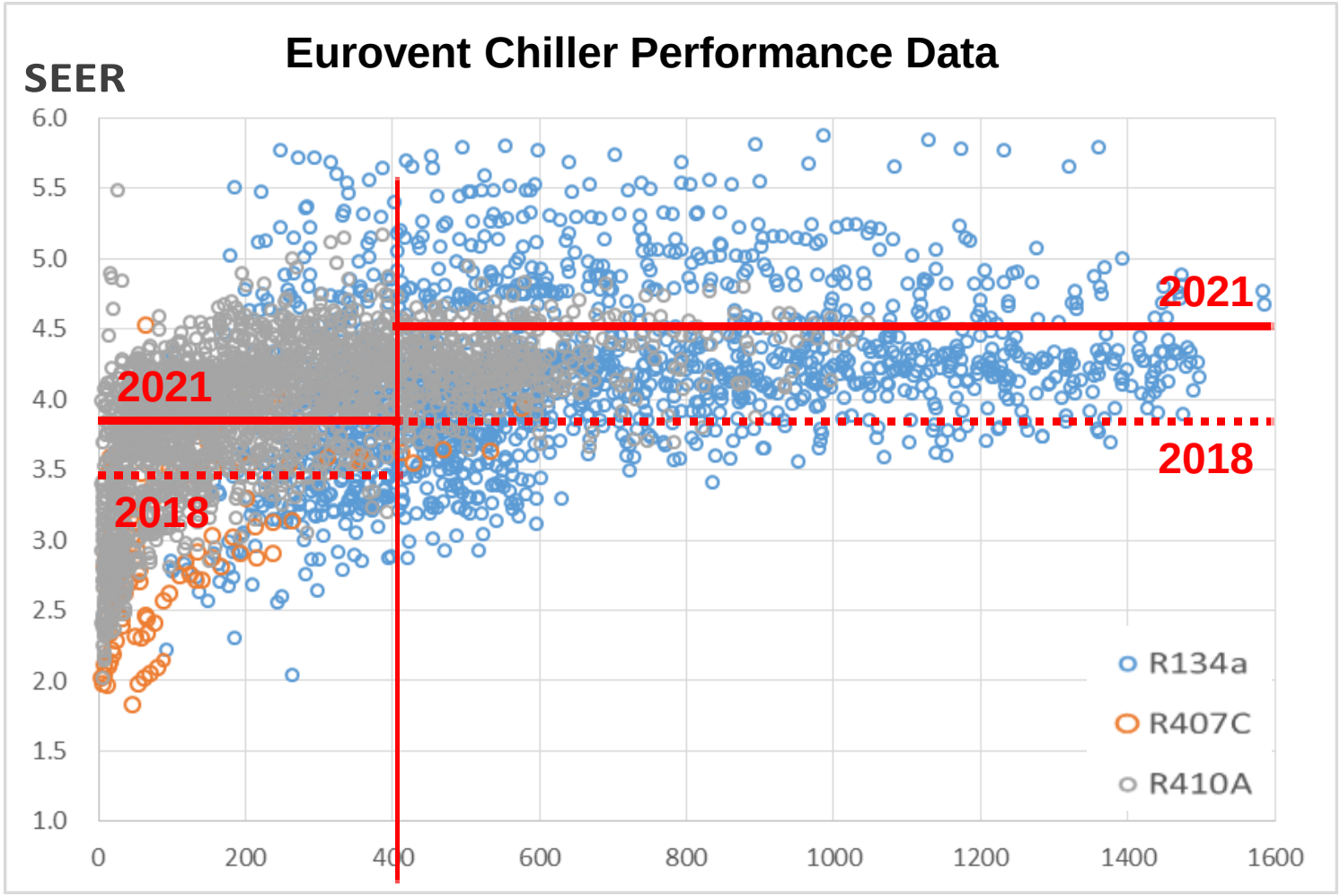
Eco-Design Implications On Chillers



Large number of chillers will not meet MEPS targets

Review Of The Solstice® Family

Solstice® Low GWP Refrigerants:
Winner of the Low Carbon Achievement of the Year

Solstice® HFO molecules Low and medium pressure applications			
	Nonflammable (ASHRAE A1)	Mildly flammable (ASHRAE A2L)	Examples of potential applications
R-134a GWP=1300		**Solstice® yf** GWP* < 1	Auto A/C, Vending, Refrigerators
		Solstice® ze GWP* < 1	Chillers, CO_2 Cascades Refrigerators
R-123 GWP= 79	**Solstice® zd** GWP* =1		Centrifugal Chillers High temperature heat pump

Solstice® Blends			
	Non Flammable (ASHRAE A1)	Mildly Flammable (ASHRAE A2L)	Examples of potential app.
R-134a GWP=1300	**Solstice® N13 (R-450A)** GWP* = 547 **Solstice® N13az (R-515A**)** GWP* = 390		Chillers, Med-temp Refrigeration
R-404A GWP=3943	**Solstice® N40 (R-448A)** GWP* = 1273	**Solstice® L40X (R-455A)** GWP* = 146	Low-Temp Refrigeration
R-22 GWP=1760		**Solstice® L20 (R-444B)** GWP* = 295	Stationary A/C, Refrigeration
R-410A GWP=1923		**Solstice® L41 (R-447A)** GWP* = 572 **Solstice® L41y (R-452B**)** GWP* = 698 **Solstice® L41z (R-447B**)** GWP* = 740	Stationary A/C Applications

Solstice®
Refrigerants
F-Gas Ready

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Today

Coming Soon

** IPCC, AR5*
*** Provisional ASHRAE number*

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Chiller Fluids

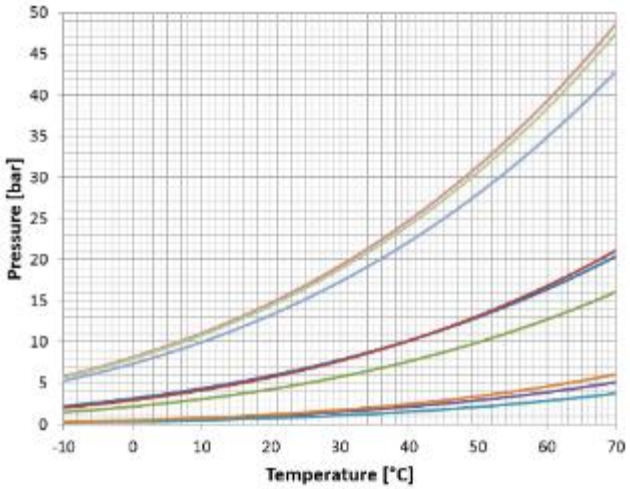
	Molar Mass	Critical Temperature ºC	Normal Boiling Point ºC	GWP	ODP
R11	137	197.6	23.71	4750	1.000
R123	153	183.68	27.82	77	0.020
Solstice® zd	131	165.5	19	1	0.000
R12	121	111.97	-29.75	10900	1.000
R134a	102	101.06	-26.07	1300	0.000
Solstice® yf	114	94.7	-29.45	1	0.000
Solstice® ze	114	109.37	-18.95	1	0.000

Some working fluids properties

- Solstice™ zd is best-suited for low pressure chiller applications
- Solstice™ yf and Solstice™ ze are best-suited to medium pressure chiller applications

HFO`s possess essential properties required for use in chiller applications

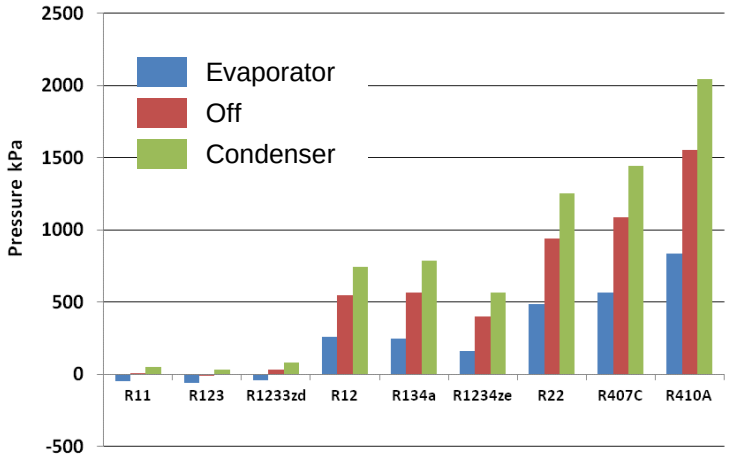
Chiller Fluids



High Pressure
R32
R410A
Solstice L41

Medium Pressure
R134a
Solstice yf
Solstice ze

Low Pressure
R245fa
Solstice zd
R123



- Operating pressures are function of refrigerant type used.
- Leaks are pressure dependant.
- Low pressure fluids are key to “leak-tight” chillers.
- Solstice™ yf and Solstice™ ze are best-suited to medium pressure chiller applications
- Solstice™ zd is best-suited for low pressure chiller applications

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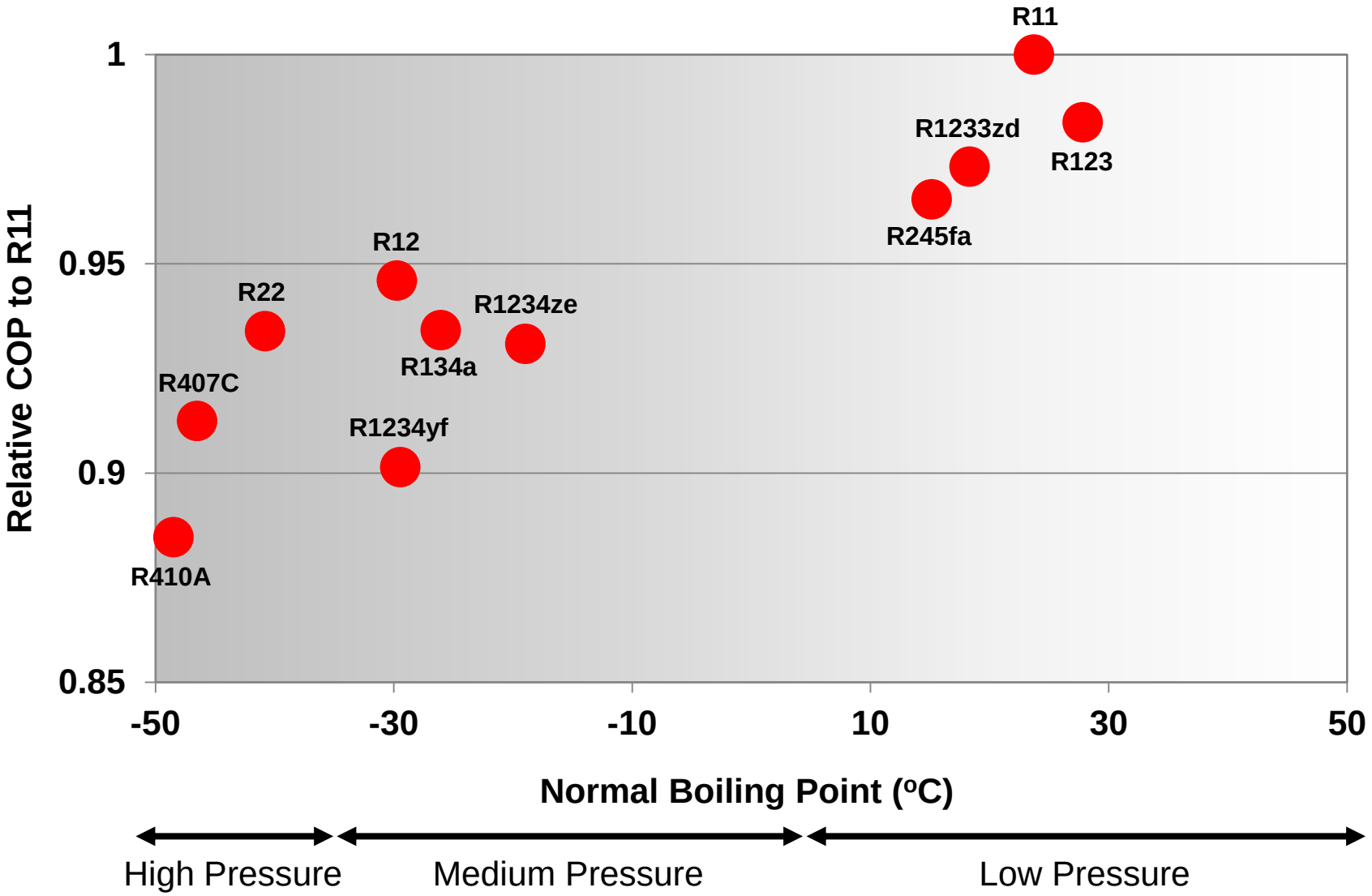
Refrigerant Cycle Efficiency



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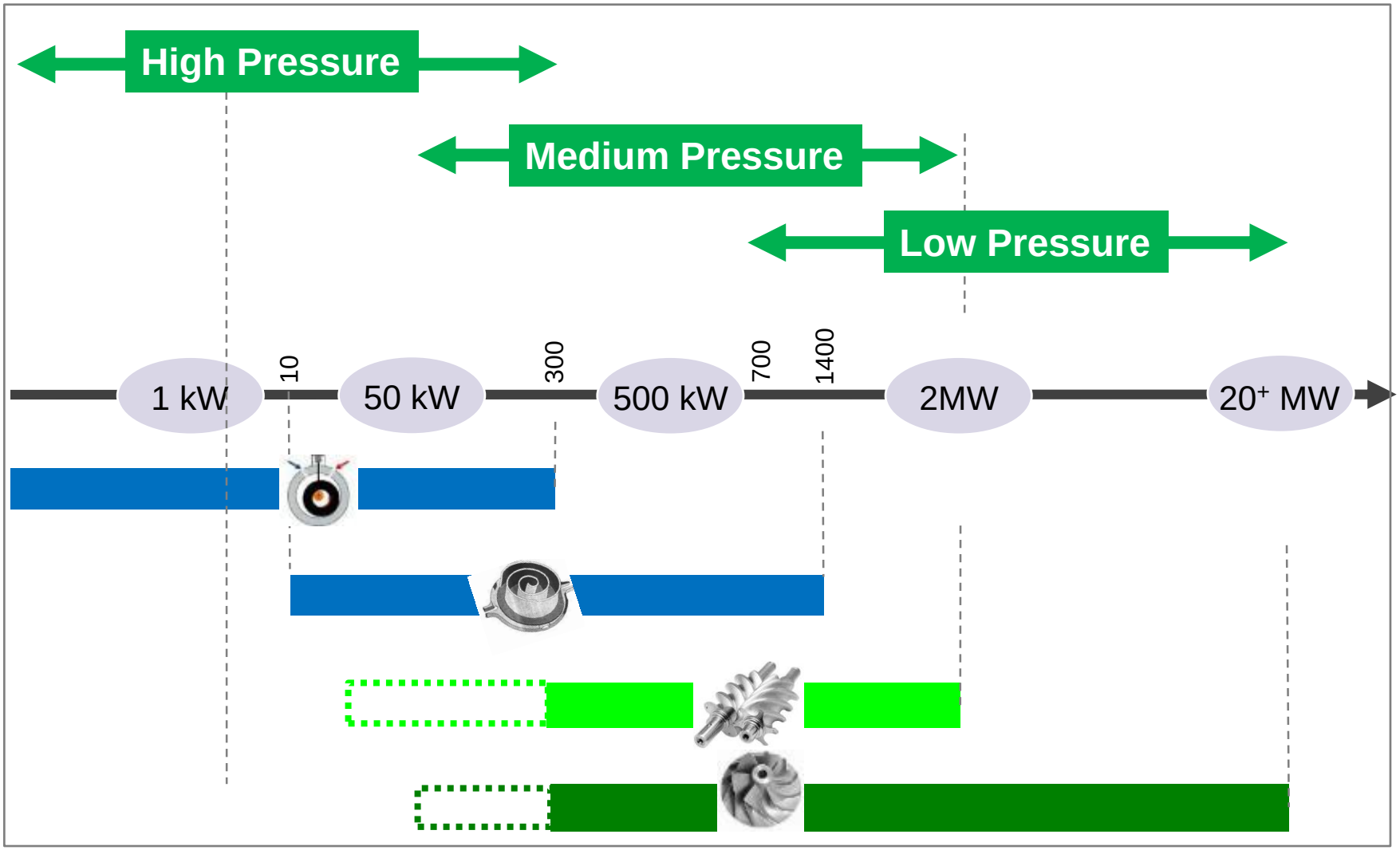
Chiller Compressor Technologies



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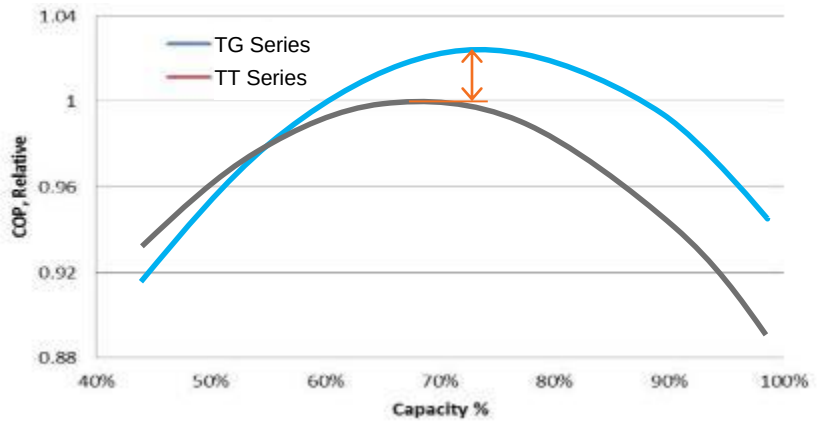
Danfoss Turbocor TG Series - HFO 1234ze Efficiency



- Energy efficiency improvements up to 3% when compared to similar R134a systems
- HFO-1234ze is the only medium pressure, ultra low-GWP alternative, without an efficiency tradeoff
- High efficiency at full load and extraordinarily high efficiency at part load conditions
- Oil-Free avoids challenges refrigerant/lubricant and heat exchangers fowling

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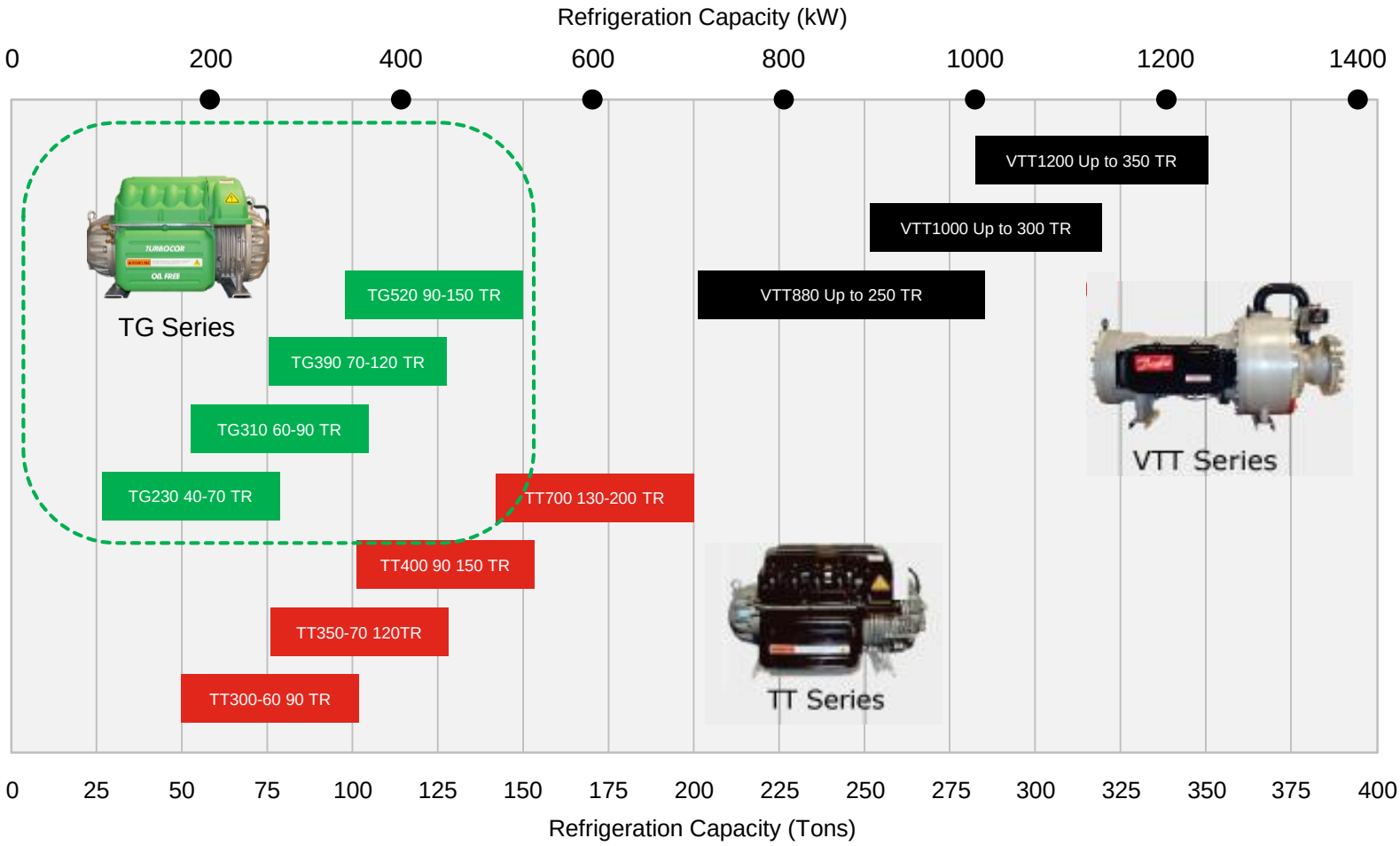
Expanded Series Of TG Compressors

Danfoss Turbocor Compressor Portfolio



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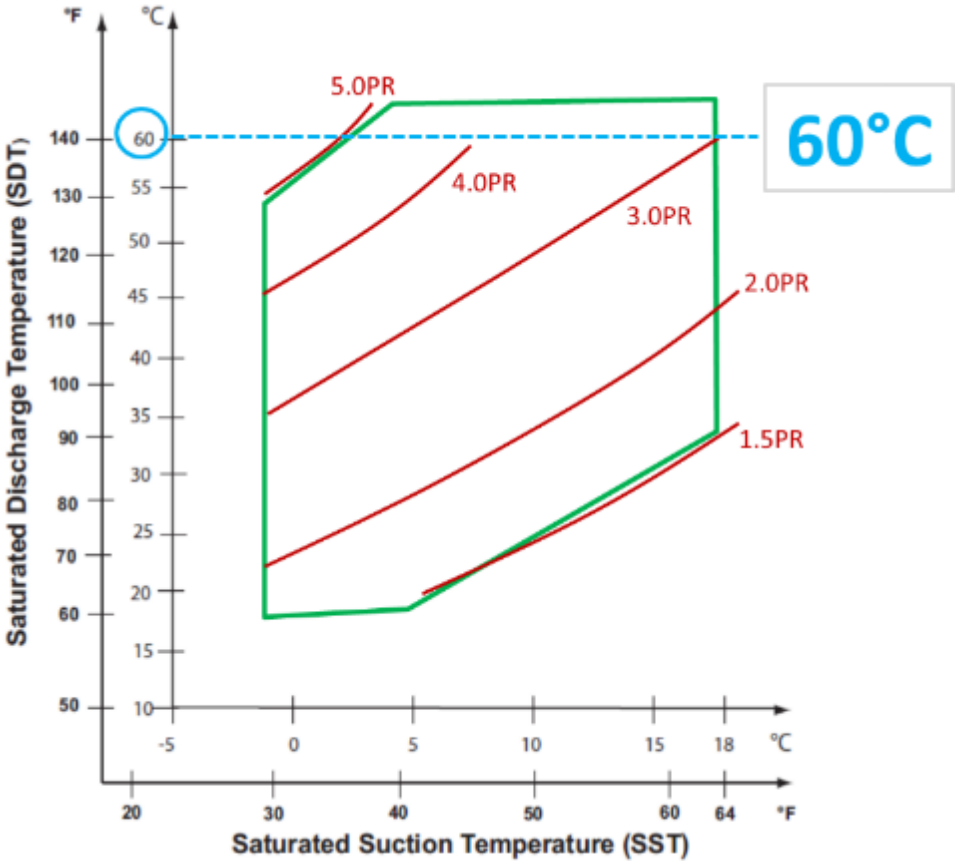
Operating Envelope Same As R134a

TG Series – Air Cooled Capable Range



TG230
TG310

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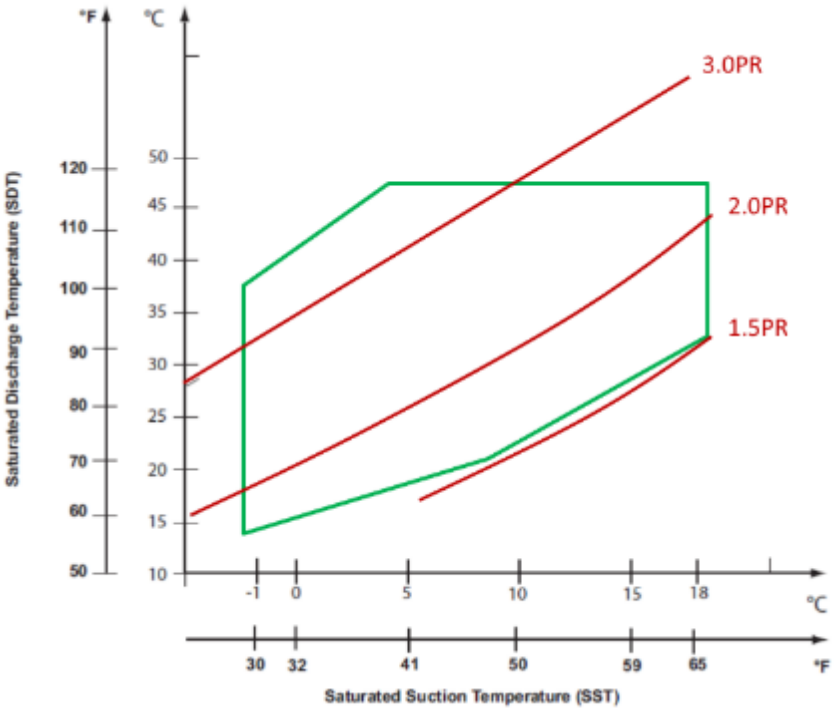
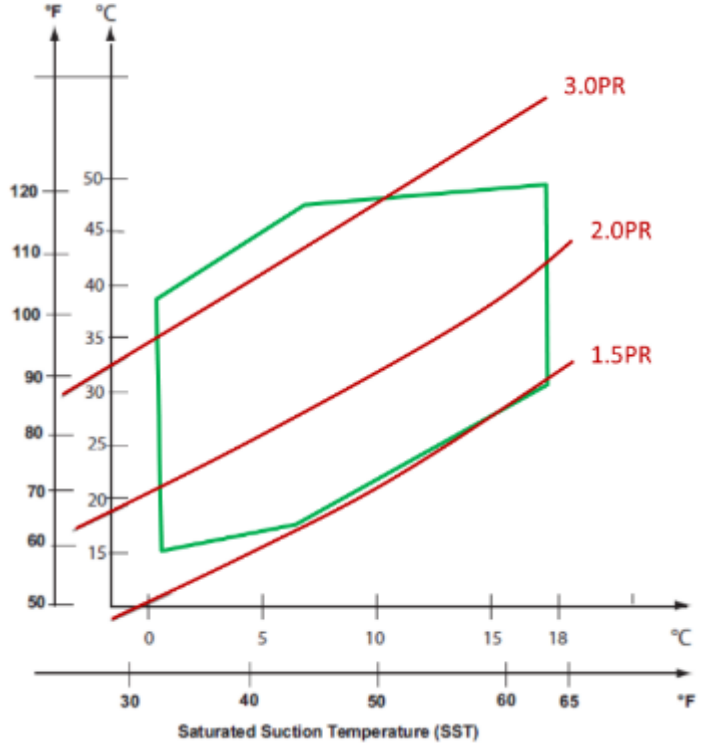
Operating Envelope Same As R134a

TG Series – Water Cooled Capable Range



TG390



TG520

Frascold CX Compressor – 1234ze Series

FRASCOLD Screw Compressors Series CX approved for HFO refrigerants

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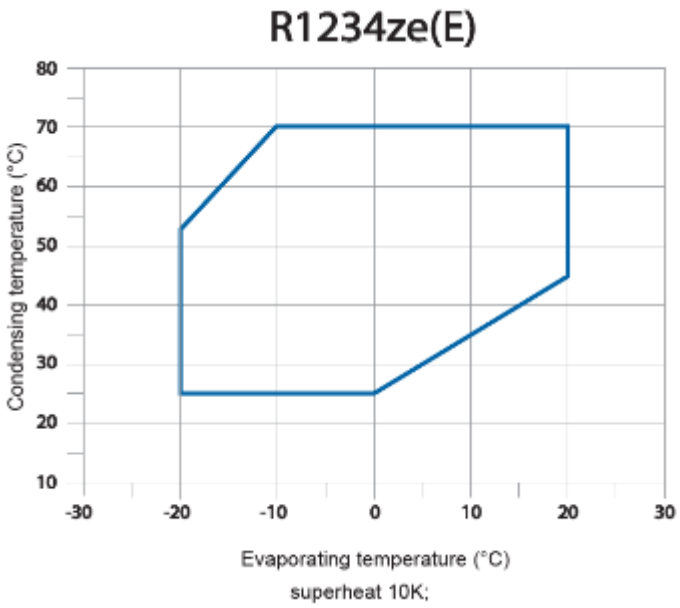
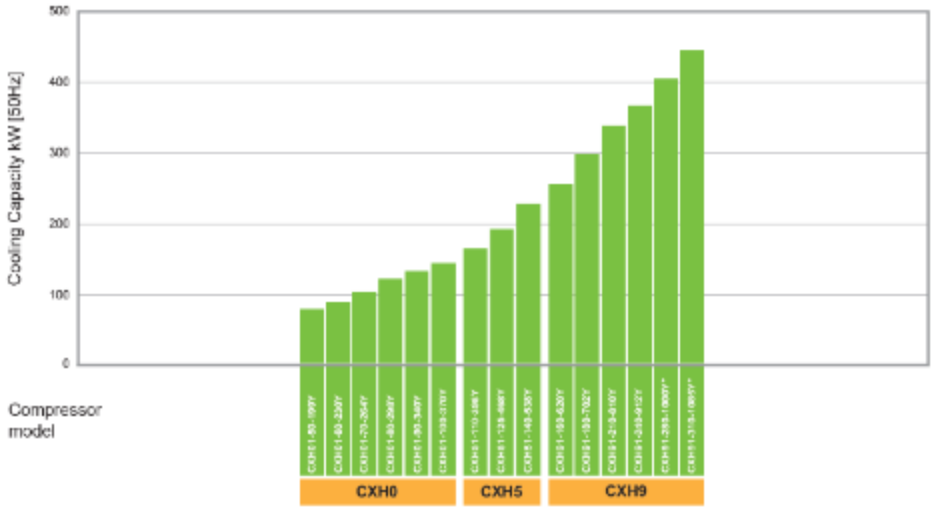
Frascold CX Compressor – 1234ze Series





http://www.frascold.it/public/files/files/FCOM060_02_EN.pdf

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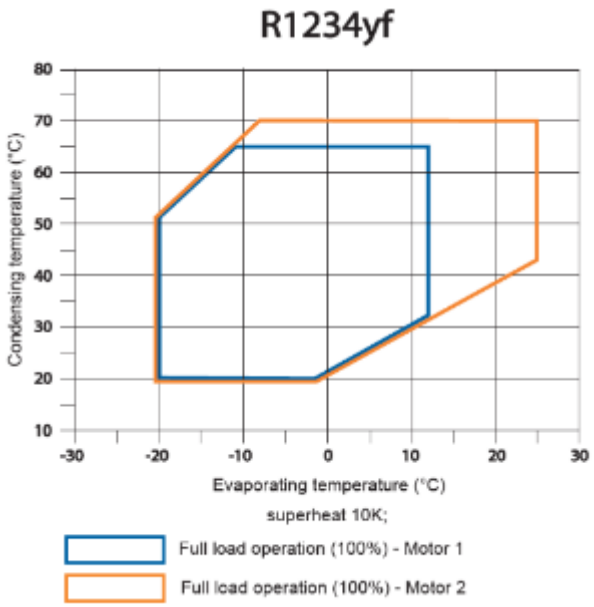
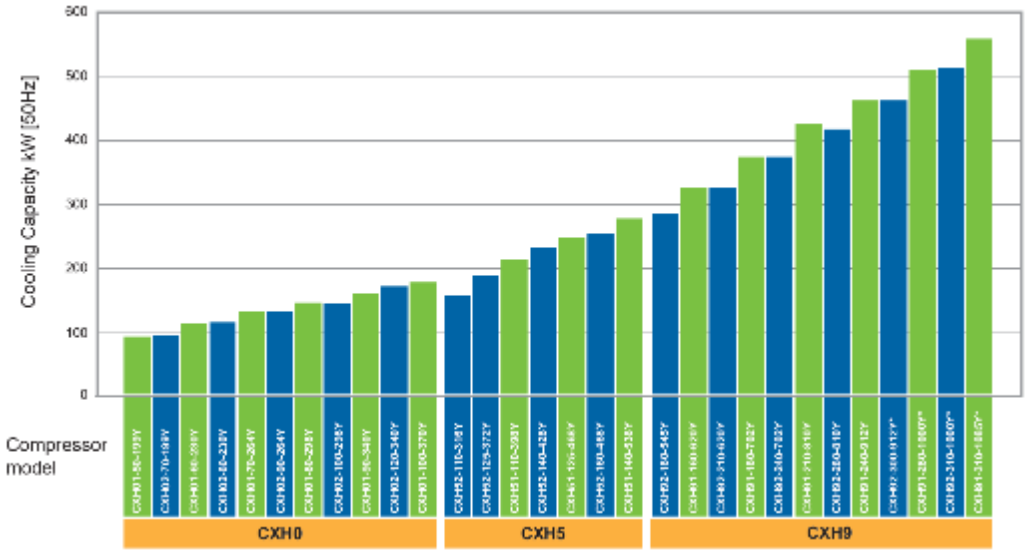
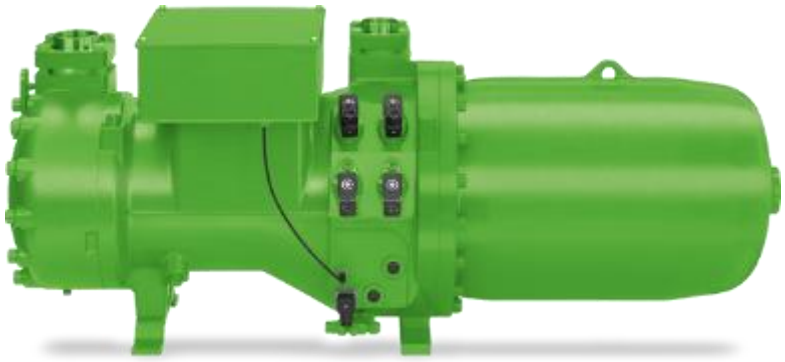
Frascold CX Compressor – 1234yf Series





Bitzer Compact Screw Compressors

The "CSH" has been selectively developed with a view to its application in air cooled liquid chillers and heat pumps intended for operation at higher condensing temperatures.



The "CSW" series has been developed for use at lower condensing temperatures, as is usual in countries with cooler climates or when using water-cooled condensers.

Products developed for refrigerants like R1234yf, R1234ze and low GWP.

high efficiency in full and part load

- Efficiency improvements of motor and mechanics
- High system efficiency in part load operation
- Optimized mechanical capacity regulation
- Specially developed frequency inverters

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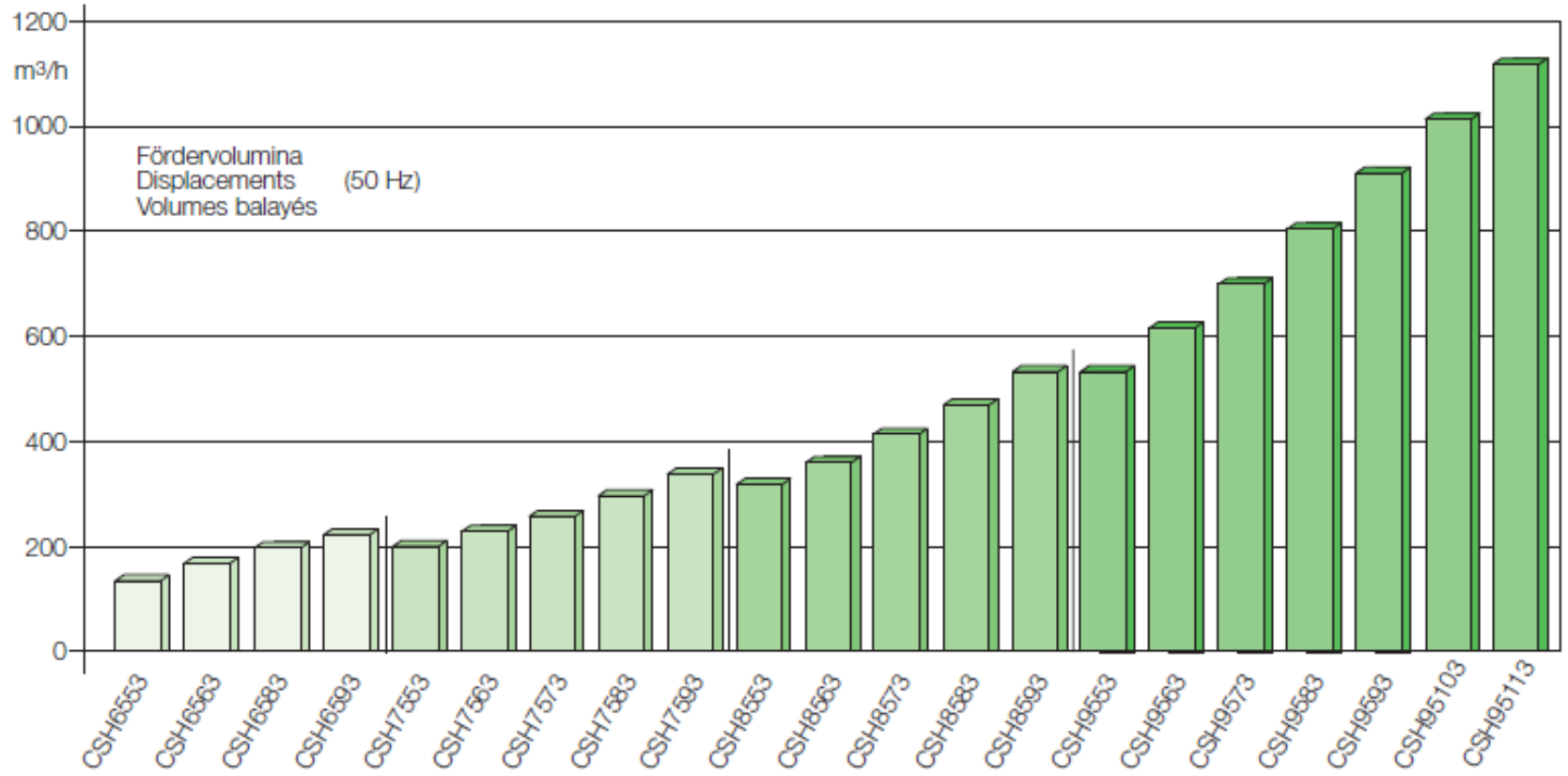
Bitzer Compact Screw Compressors



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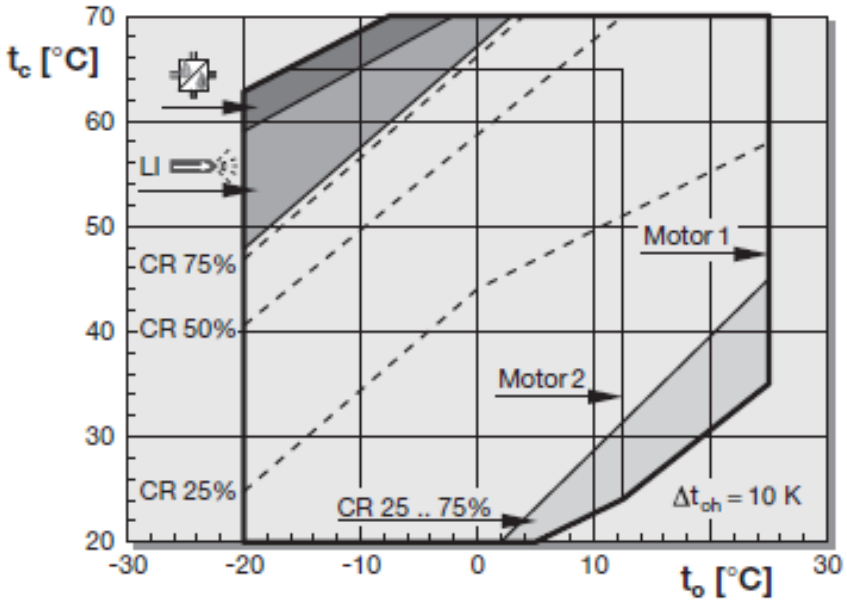
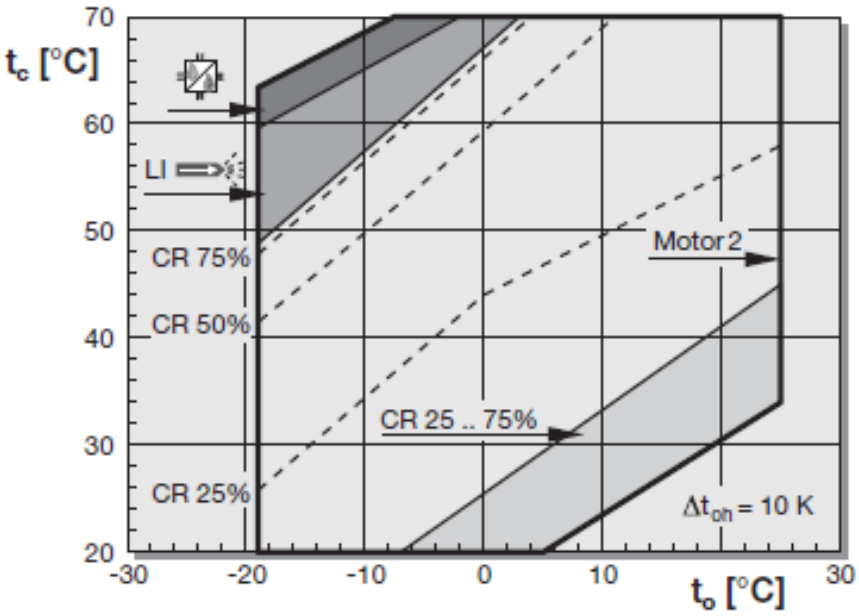
Bitzer Compact Screw Compressors

Application Limits

R1234yf & R134a standard



R1234ze



Carrier AquaForce Chiller

- 4 years of development work, 320 fluids investigated
- HFO1234ze with Screw compressor technology identified as best choice in terms of Efficiency
- All components and Oil have been qualified for HFO1234ze
- Field trials in progress in various regions. Switzerland (19), France(3), Norway(1), Holland(1)

http://www.coolingpost.com/world-news/carrier-sees-future-in-r1234ze/

https://www.youtube.com/watch?v=wVhMGGTK5WQ

https://www.youtube.com/watch?v=k3FgzXxIut4

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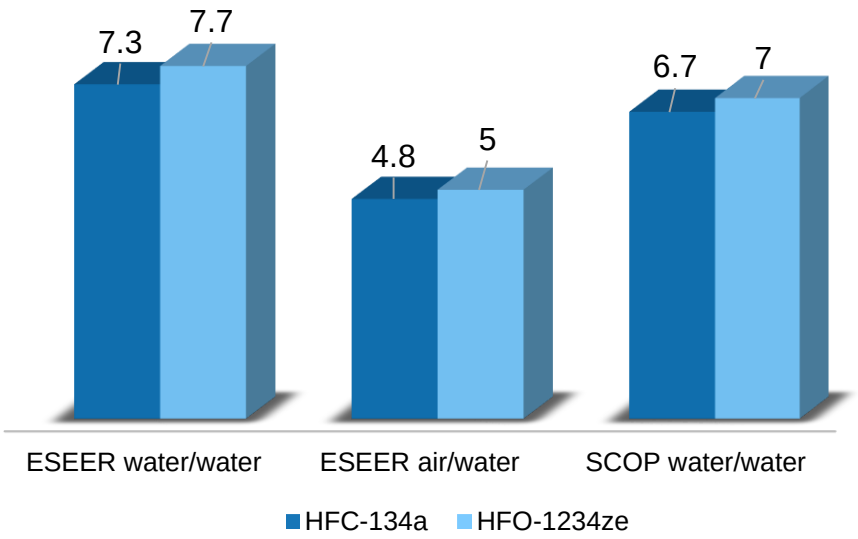
Carrier AquaForce Chiller



On average 5% higher efficiency vs R134a Chiller

http://www.coolingpost.com/world-news/carrier-sees-future-in-r1234ze/

https://www.youtube.com/watch?v=k3FgzXxIut4

https://www.youtube.com/watch?v=wVhMGGTK5WQ

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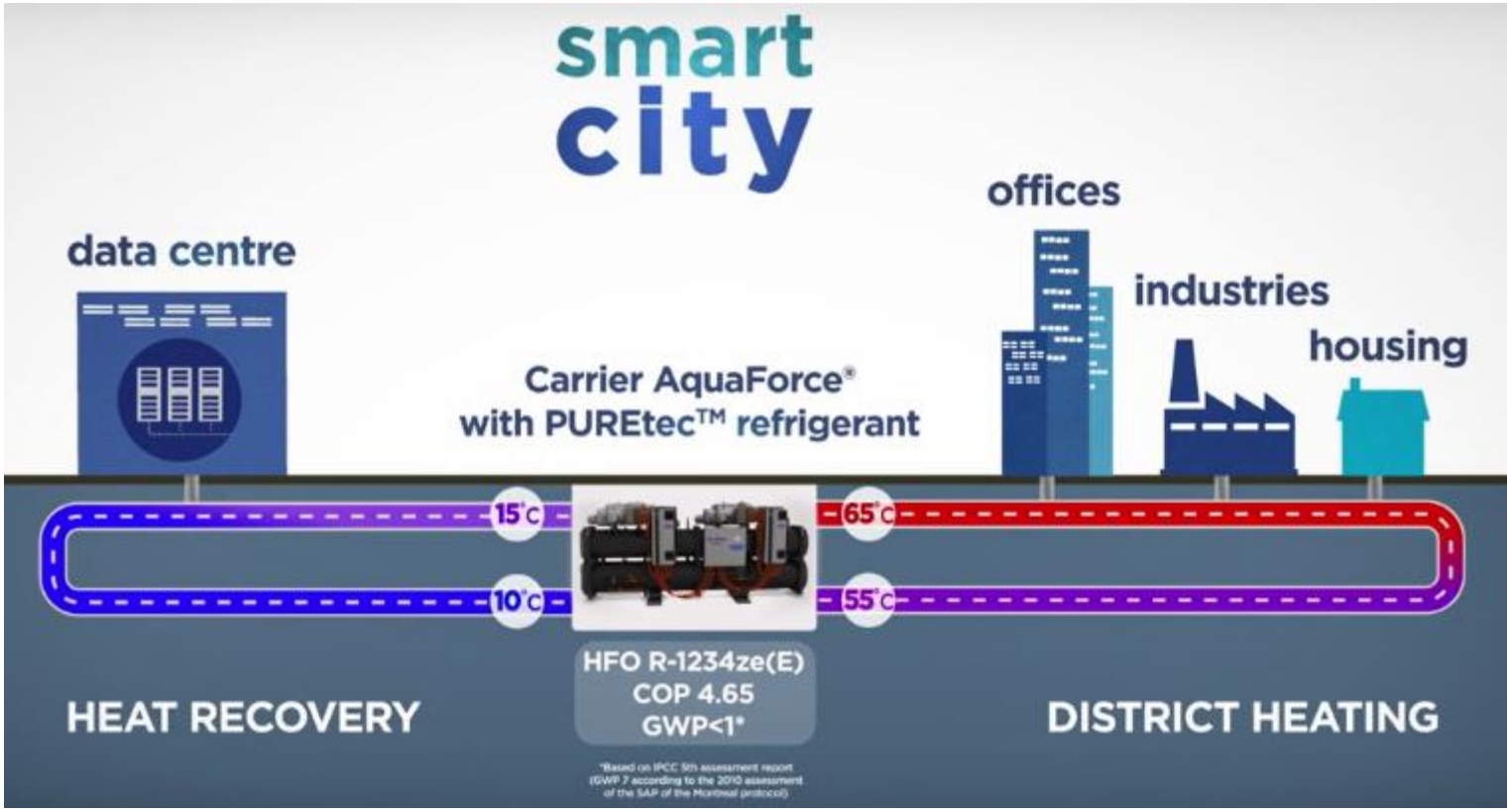
Case Study: Plan-les-Ouatres Geneva



Data Centre Cooling and 4.5MW of heating (+Hot Water) to offices, Industry and 3000 homes.

https://www.youtube.com/watch?v=wVhMGGTK5WQ#t=122.4806597

http://www.coolingpost.com/world-news/carrier-latest-to-install-r1234ze-chiller/

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TRANE CenTraVac™ Chiller

R-1233zd based chillers are now part of TRANE European product range.

CVHH

- 3-Stage Direct Drive
- Heat Recovery

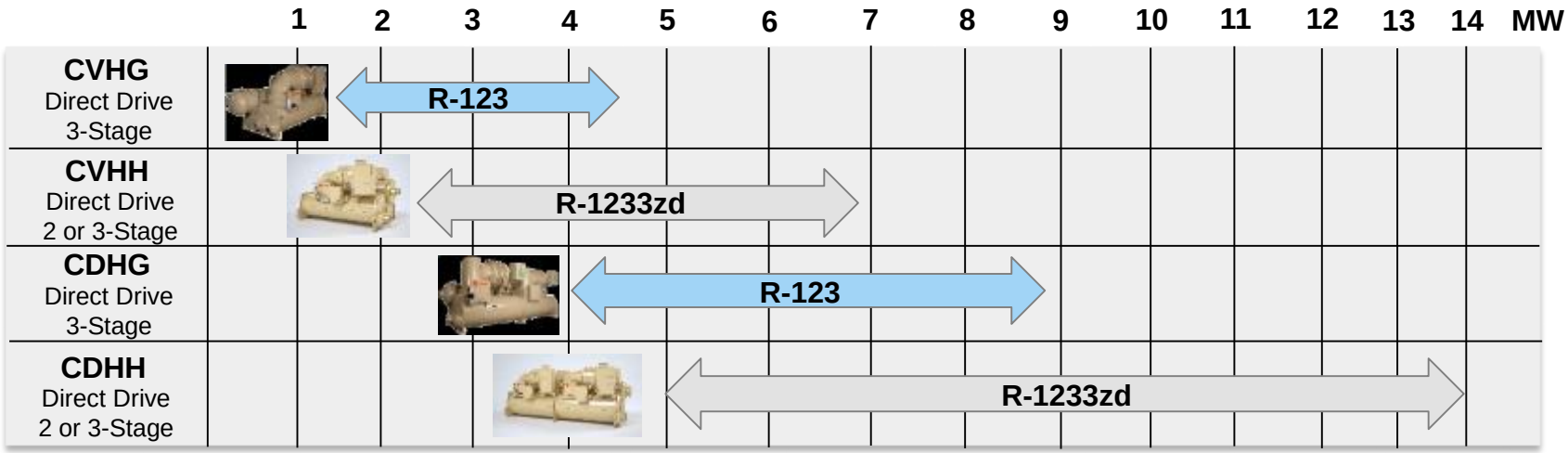
CDHH

- 3-Stage Direct Drive
- Dual Refrigerant Circuit

R1233zd ensures Low Pressure Centrifugal Technology Revival

TRANE CenTraVac™ Chiller

- The First Low Pressure Centrifugal Chiller using 1233zd, released by TRANE
- Range extended to 14MW (largest HFO Chiller Capacity on the market)
- Up to 13.5% more energy efficiency than the next best chiller available in this tonnage range
- Combining high efficiency benefits associated with low pressure fluids and high capacity due to slightly higher pressure than R123



Market Leading Efficiency/Capacity achieved with 1233zd

Solstice® zd Cools The Channel Tunnel

the largest HFO chiller installation of its kind in the world, Trane CenTraVac's using R1233zd(E) will replace the existing R22 chillers serving the Channel Tunnel.*

One of the new Trane chillers during installation in the Sangatte plant*

* http://www.coolingpost.com/world-news/hfo-chillers-to-cool-the-channel-tunnel/

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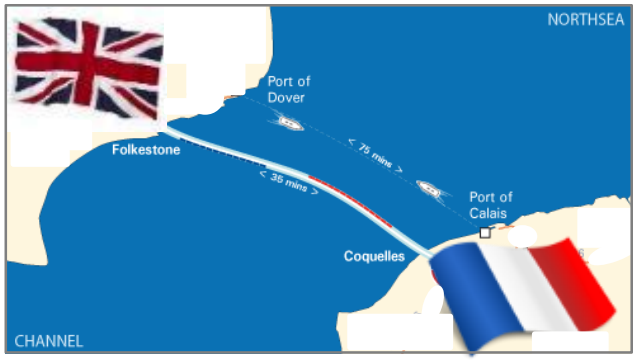
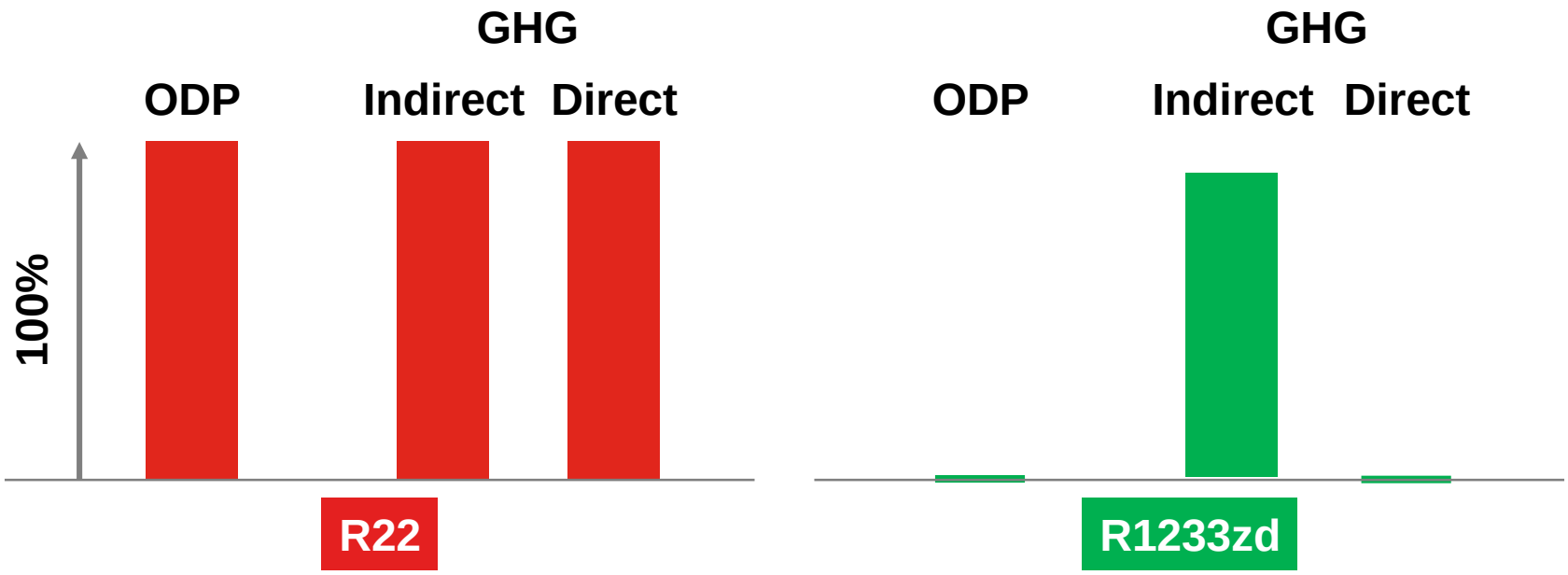
Solstice® zd Cools the Channel Tunnel



- Solstice zd Chosen for the renovation of the channel tunnel refrigeration system
- 4 New Solstice zd Chillers replaced R22 old system
- Each chiller providing 26MW cooling load, to maintain tunnel temperature below 25°C
- 10% Higher energy efficiency with savings of 200 000 euros/year

* http://www.coolingpost.com/world-news/hfo-chillers-to-cool-the-channel-tunnel/

Environmental Impact



The transition to R1233zd has reduced considerably the environmental footprint of the Channel Tunnel:

- No Ozone depletion
- 10% reduction in indirect emissions
- No direct emissions

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Recent Solstice® Launches

Solstice zd chillers

- Trane High Efficiency Chillers
- Mitsubishi Heavy Electric

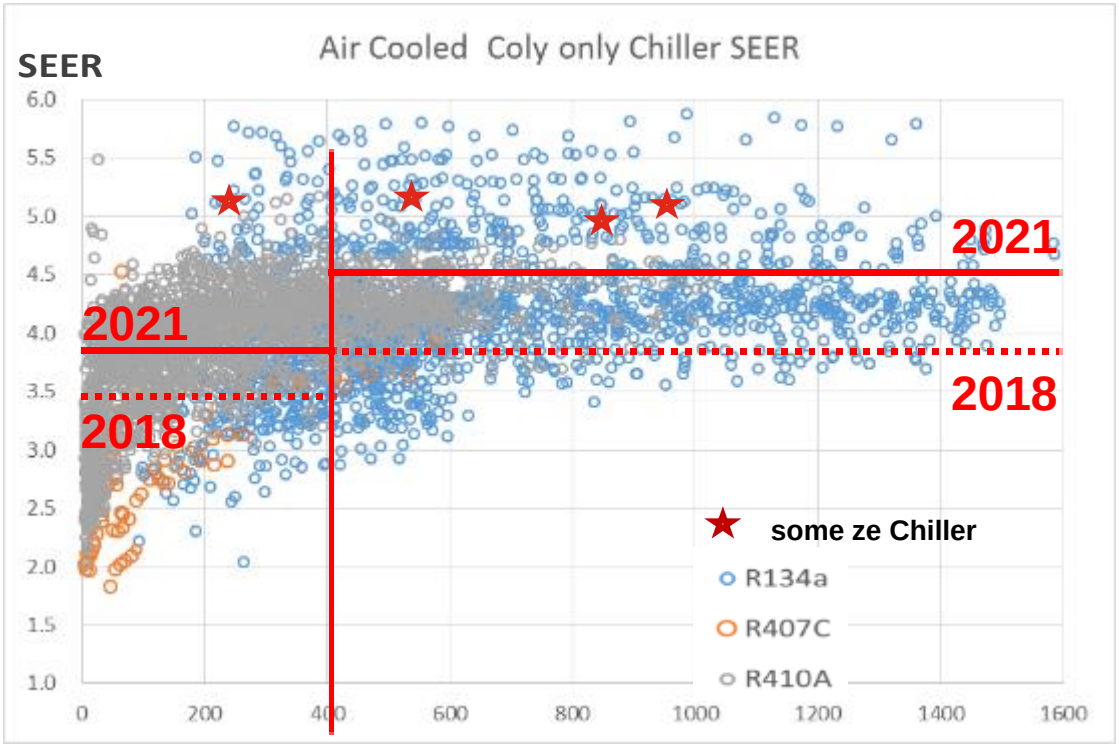
Solstice ze chillers/heat pumps

- Carrier Aqua Force screw chillers
- Danfoss Turbocor compressor for 1234ze
- Friotherm district heating & cooling
- Geoclima screw and centrifugal
- Star Refrigeration high efficiency Turbocor
- Airedale chillers with free cooling
- Cofely Turbocor chiller
- Multistack screw chiller
- Cooltherm chillers
- Smardt chillers
- Blue Box
- RC high efficiency screw chiller, wáter- and air-cooled chillers
- Climaveneta
- Rhoss
- Aermec
- Viessmann…

Industry converting, regular announcements of new launches

Eco-Design Implications On Chillers

Eurovent Chiller Performance Data



- Large number of chiller will not meet MEPS targets
- Solstice® ze chiller with variable speed compressor excceed the MEPS

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Summary

- Honeywell Fluorine Products has Established Technical Leadership in Offering Energy Efficient and Environmental Friendly Solutions
- Solstice® Low Global Platform Covering a Broad Spectrum of Applications are Being commercialized Globally
- Solstice® ze successfully replacing R134a in medium pressure chillers
- Solstice® zd matches R123 efficiency with higher capacity in low pressure chillers.
- Solstice® Platform ready to meet F-Gas Cap & Phase Down Needs in Europe and Support High Growth Region’s

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Solstice® Refrigerants

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See us in Hall 6, booth 6-130