

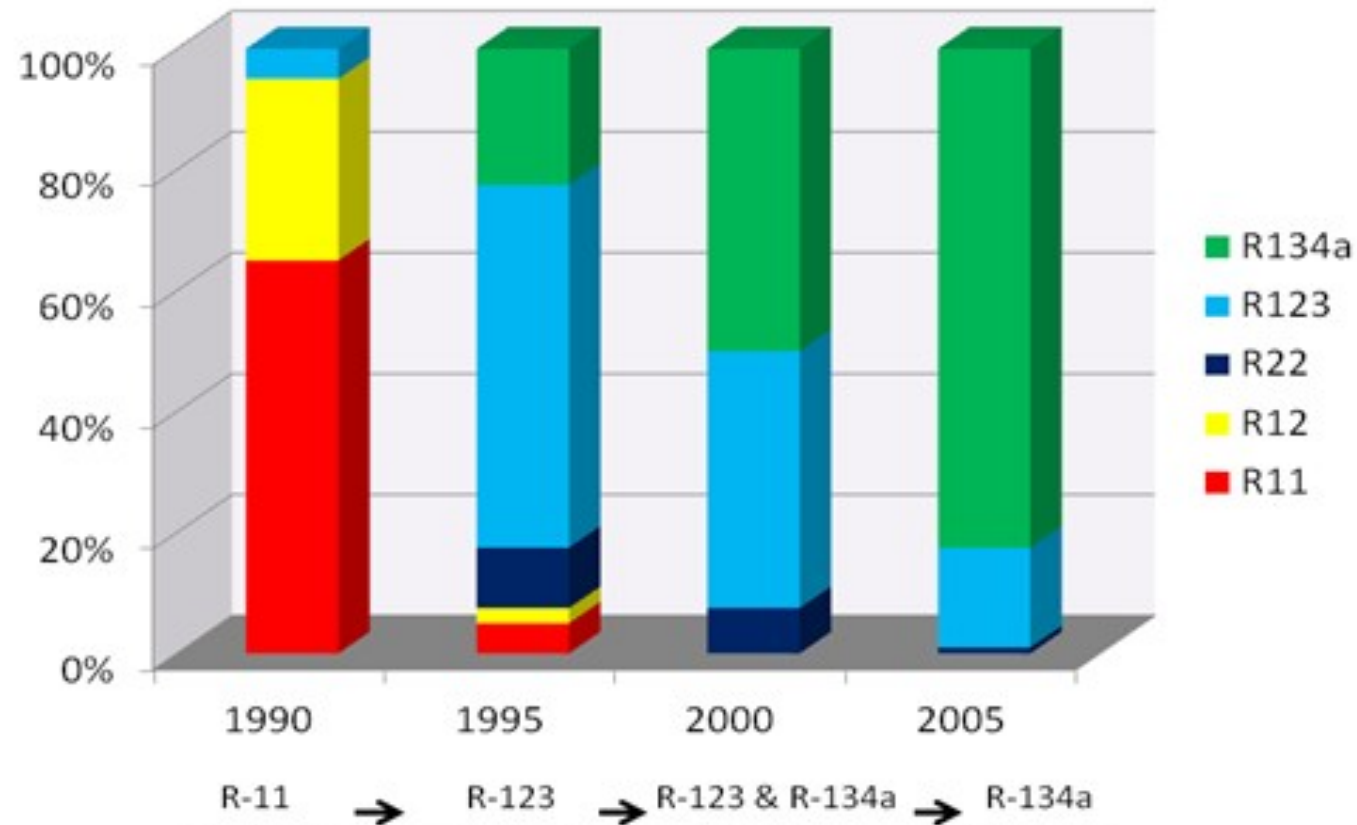


Tunca Sekban,  
Honeywell

# LOW GWP REFRIGERANT SOLUTIONS FOR CHILLER APPLICATIONS

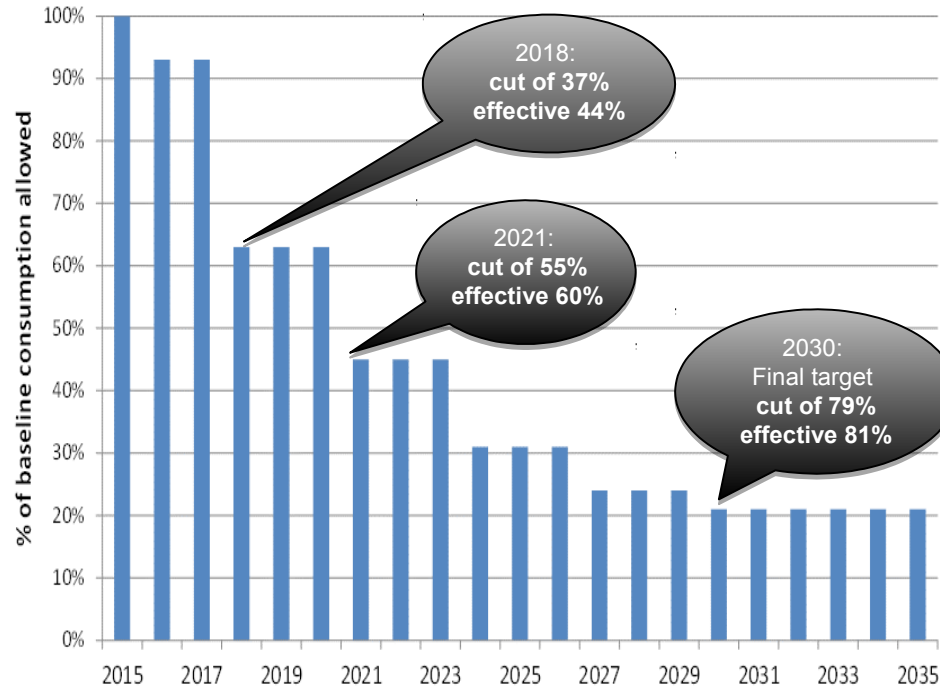
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# Centrifugal Chiller Market Shift

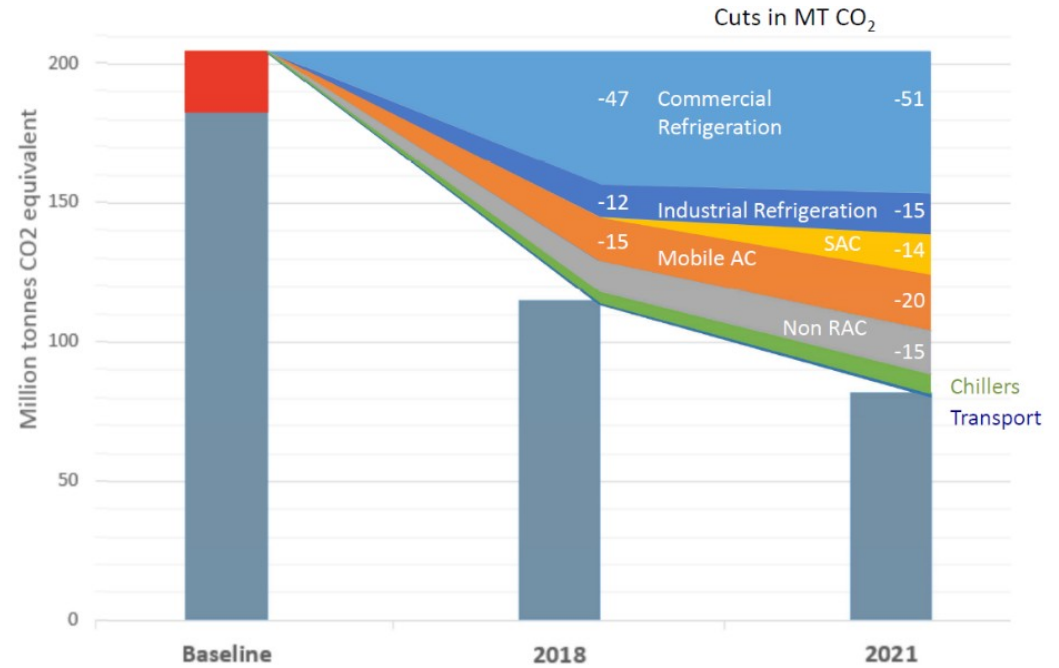


- Low GWP solutions required to reduce direct impact

# F-Gas Implications

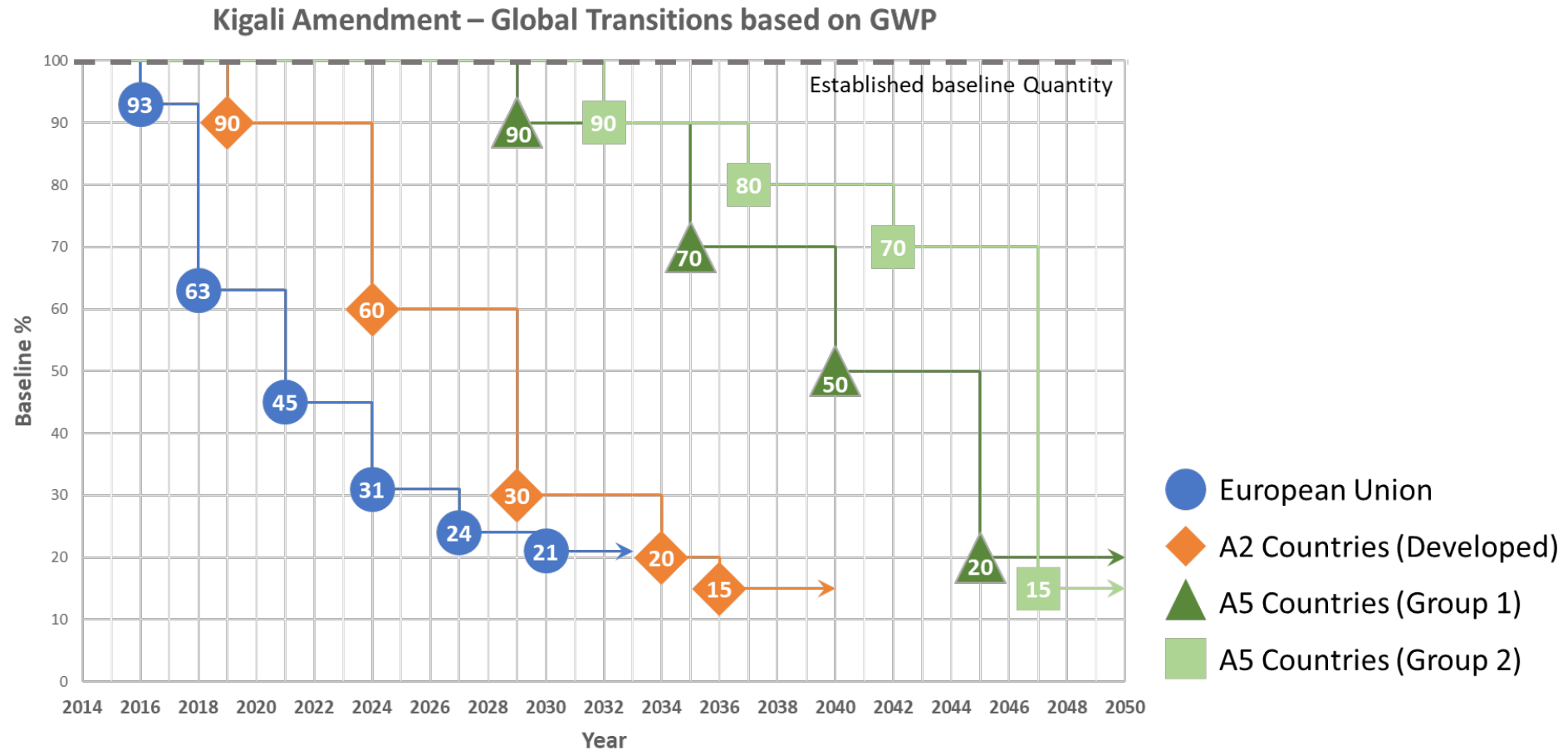


Phase-down controlled by a quota allocation system

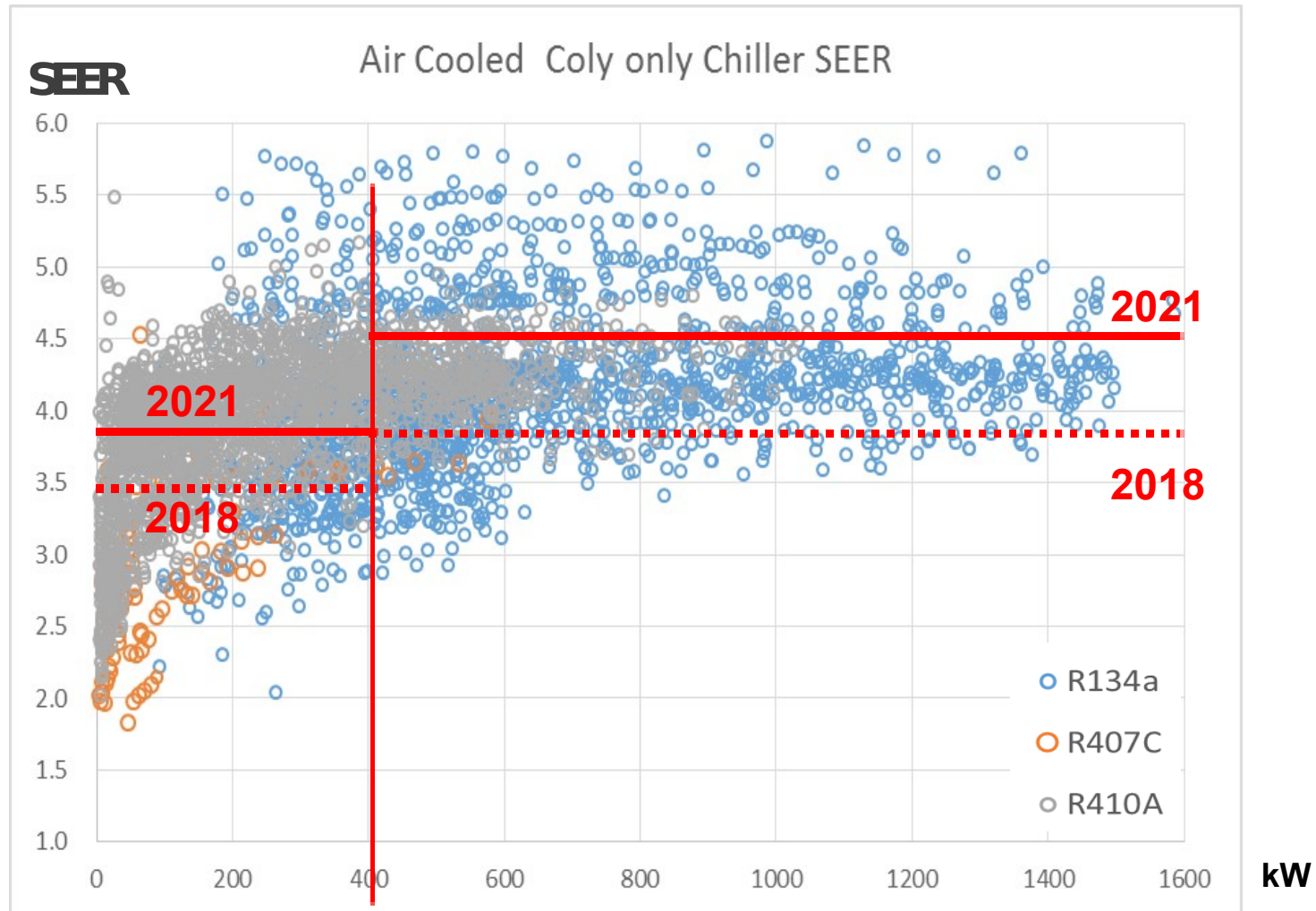


- Although chiller contribution to carbon emission is low, declining supply of HFC could become an issue over chiller lifetime

# Kigali Amendment



# Eco-Design Implications On Chillers



- Large number of chillers will not meet MEPS targets

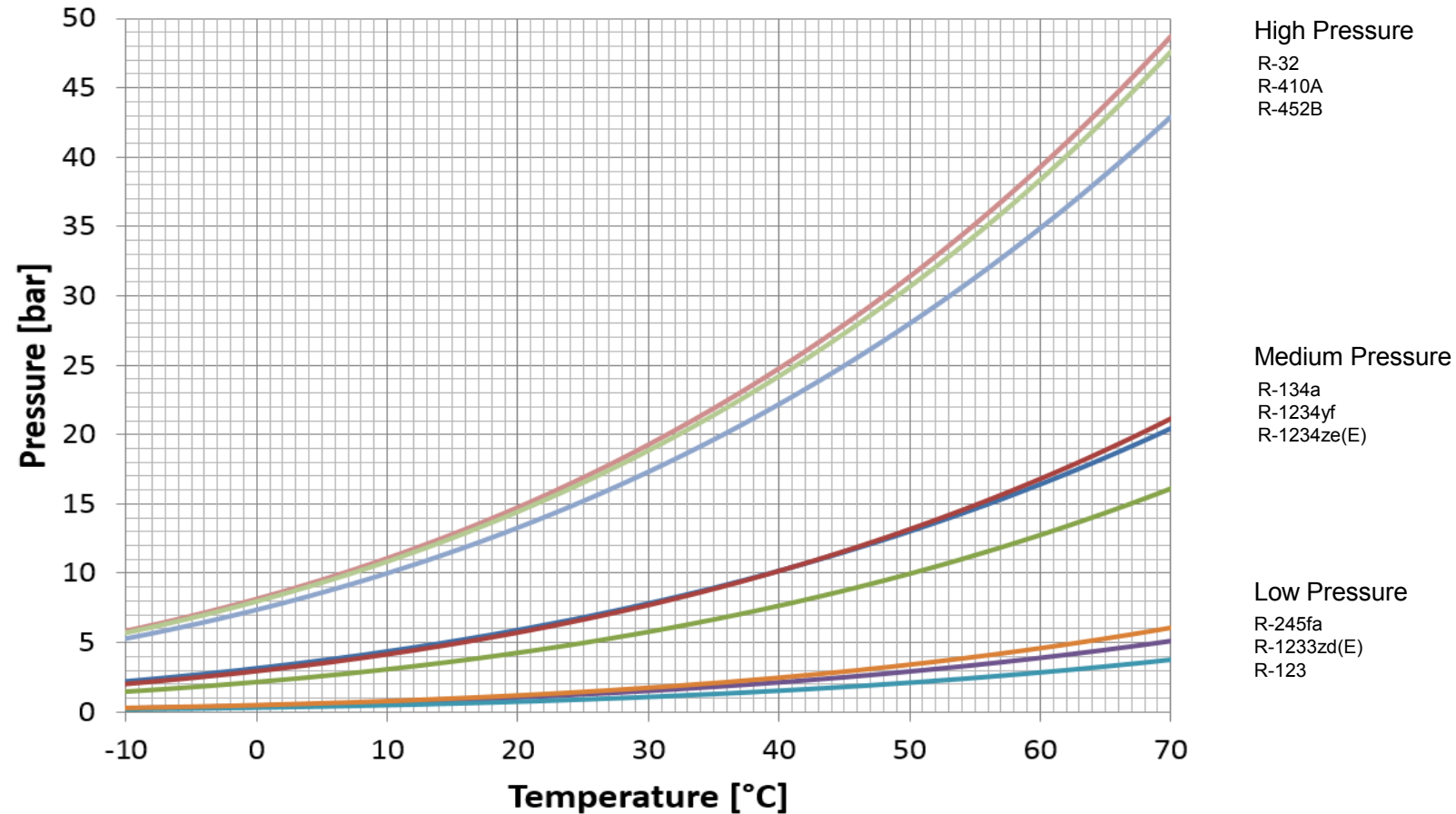
# Chiller Working Fluids

	<b>Molar Mass [g/mol]</b>	<b>Normal Boiling Point [°C]</b>	<b>GWP</b>	<b>ODP</b>
<b>R-11</b>	137	23.71	4750	1.000
<b>R-123</b>	153	27.82	77	0.020
<b>R-1233zd(E)</b>	131	19	1	0.000
<b>R-12</b>	121	-29.75	10900	1.000
<b>R-134a</b>	102	-26.07	1300	0.000
<b>R-1234yf</b>	114	-29.45	1	0.000
<b>R-1234ze(E)</b>	114	-18.95	<1	0.000
<b>R-22</b>	86	-40.81	1810	<b>0.055</b>

## Some working fluids properties

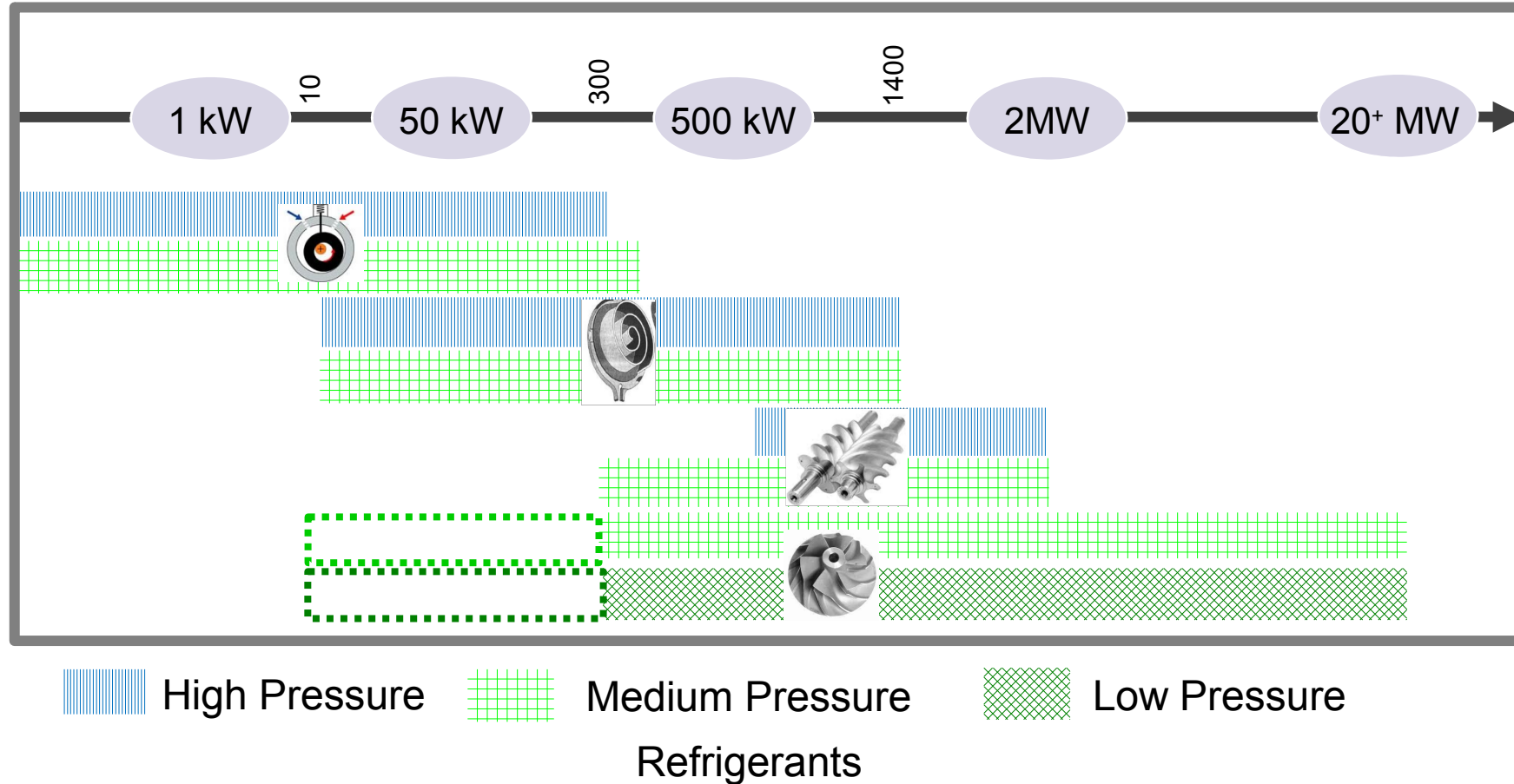
- R-1233zd(E) suits to low pressure chiller applications
- R-1234yf and R-1234ze(E) suit to medium pressure chiller applications
- Large The new refrigerants also possess essential properties required for use in chiller applications

# Operating Pressures



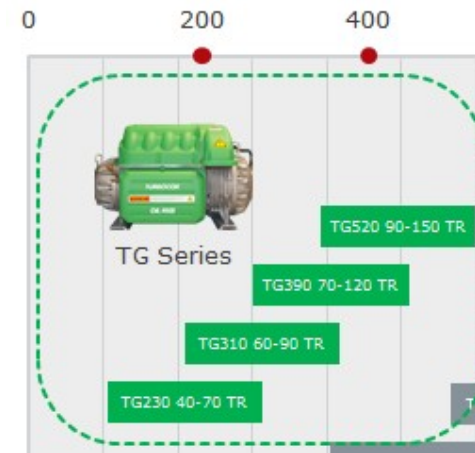
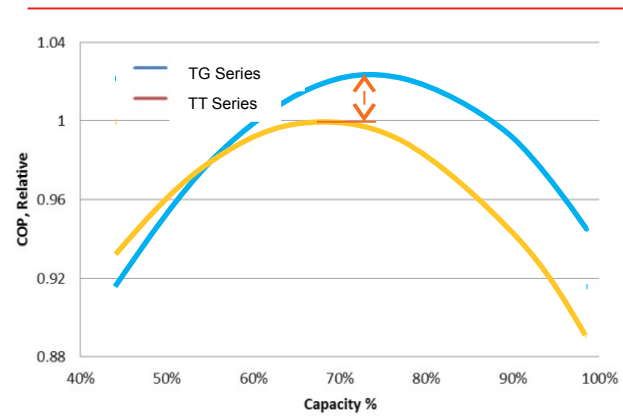
- Operating pressures are function of refrigerant type used
- Leaks are pressure dependant
- Low pressure fluids are key to “leak-tight” chillers

# Compressor Technology vs. Chiller Capacity





# Danfoss Turbocor TG Series – HFO-1234ze Efficiency



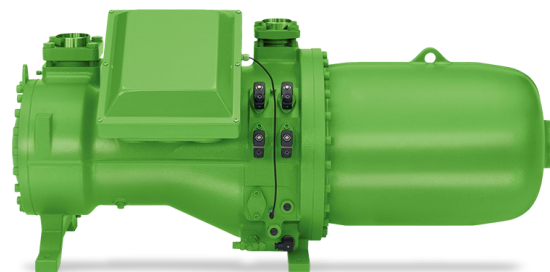
Turbocor - TG Series of Compressors – Danfoss Introduction presentation Chillventa 2016

- Energy efficiency improvements up to 3% when compared to similar R-134a systems
- HFO-1234ze is the only medium pressure, ultra low-GWP alternative, without an efficiency trade-off
- High efficiency at full load and extraordinarily high efficiency at part load conditions
- Oil free technology

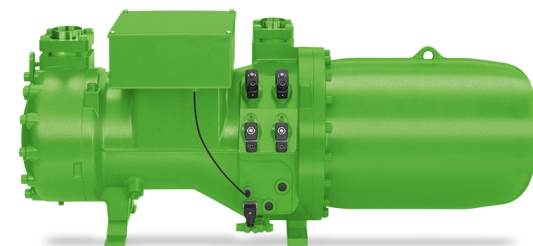
# Screw Compressors – HFO-1234ze(E) series



FRASCOLD Screw Compressors Series CX approved for HFO refrigerants



Bitzer "CSH" : application in air-cooled liquid chillers and heat pumps intended for operation at higher condensing temperatures.



Bitzer "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.

# First HFO Chiller



- Developed by Geoclima in 2010
- Using R-1234ze(E) to replace R-134a
- Used for a water loop in a UK supermarket
- In operation since 2011 and no issues reported
- Geoclima reported 3.5% better COP on average vs equivalent R-134a chiller
- More efficient than the HC version used by the same supermarket chain
- Geoclima has optimized HFO based chiller designs, now offering a full range of chillers using R-1234ze

# GVAF Air Cooled Chillers R-134a vs R-1234ze(E)

Model Name	GVAF XP 245 LN	GVAF XPG 245 LN	
Refrigerant	R-134a	R-1234ze	
GWP	1300	<1	-99.9%
Cooling Capacity (kW)	878	878	
EER	3.48	3.72	
ESEER	5.30	5.65	+6.9%
Power Consumption (kW)	252	236	+6.6%



Source: [www.eurovent-certification.com](http://www.eurovent-certification.com)

- Efficiency, an important criteria in chiller selection

# Channel Tunnel Application



The largest HFO chiller installation of its kind in the world, Trane CenTraVac's using R-1233zd(E) replace the existing R-22 chillers serving the Channel Tunnel.\*

- R-1233zd(E) chosen for the renovation of the channel tunnel refrigeration system
- 4 New R-1233zd(E) Chillers replaced R-22 old system
- Each chiller providing 14MW cooling load, to maintain tunnel temperature below 25°C
- 33% drop in energy usage – 500.000€ savings in 2017

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

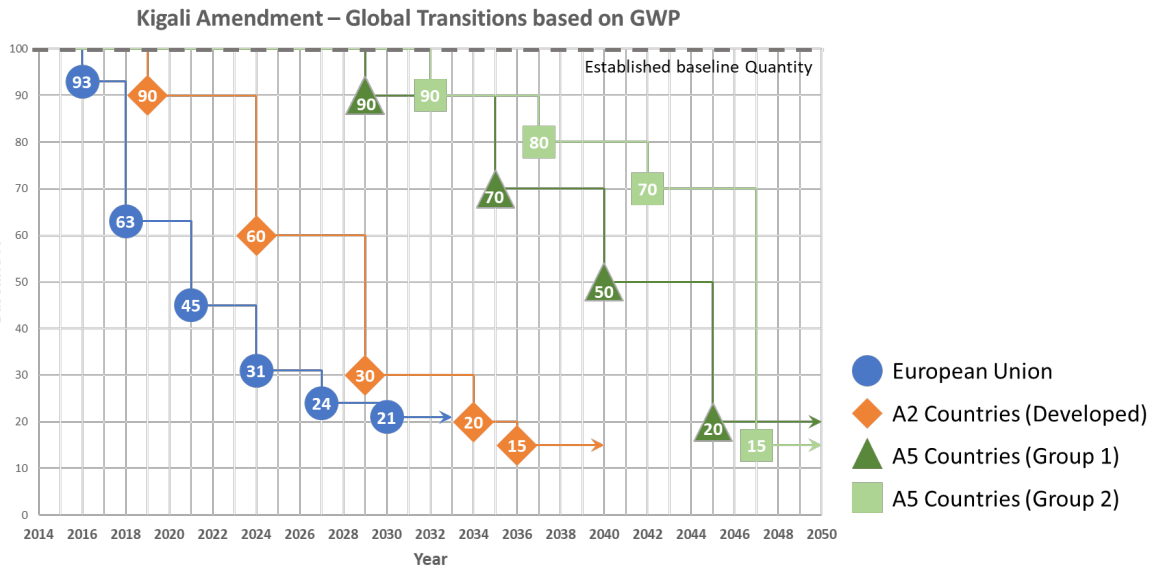
# Eurocontrol Application



The Quantum 'G' Water cooled chiller

- Eurocontrol's headquarters, flight management and data center facilities in Brussels was equipped lately with a new cooling system based on R-1234ze(E) technology
- Quantum® cooling systems produced by ENGIE Axima are designed with oil-free, magnetic-bearing centrifugal compressors replacing an older R-22 system
- The first results indicate that the cooling system's design helps achieve annual energy savings up to 1,500 MWh and reduce EUROCONTROL's total annual consumption by more than 12 percent, helping EUROCONTROL save up to €150,000 per year on energy costs.

# High Ambient Regions



Although High Growth Regions like Middle East and India are part of article 5 (group 2) countries, meaning according to Kigali agreement, are not concerned immediately with the phase down, and HCFCs are still widely used refrigerants, some manufacturers have shown interest and initiated development of HFO chillers.

These regions are also characterized by high ambient conditions, and therefore it is important not only to provide a low GWP solution but also to demonstrate that the solution works efficiently under the high ambient experienced in the region.

# Kirloskar HFO Chiller



Kirloskar water cooled R-1234ze(E) chiller



Kirloskar initial test results

- Kirloskar is one of the leaders in chiller technology in India and has developed a new chiller based on R-1234ze(E)
- Equipped with screw compressor, water-cooled condenser and flooded shell & tube evaporator. It chills water at delta t of 5 K
- Chiller is little less on capacity but matches the efficiency of R-134a chiller with significant reduction in compressor power



# Conclusion

- Recently developed LGWP molecules have been evaluated in low and medium pressure centrifugal chillers. Comparable performance to existing refrigerants can be achieved in applications investigated to date without significant hardware modification
- R-1234ze(E) successfully replacing R-134a in medium pressure chillers
- R-1233zd(E) matches R-123 efficiency with higher capacity in low pressure chillers
- Majority of chiller manufacturers have adopted these new fluids and the number of field installations is increasing
- It is expected that with increasing pressure from the eco-design, more and more chillers will be offered with HFOs in order not only to use a low GWP fluid but essentially to have better performance and comply with the eco-design directive.

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