

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



October 2016

R-455A – A NEW GLOBAL REFRIGERANT

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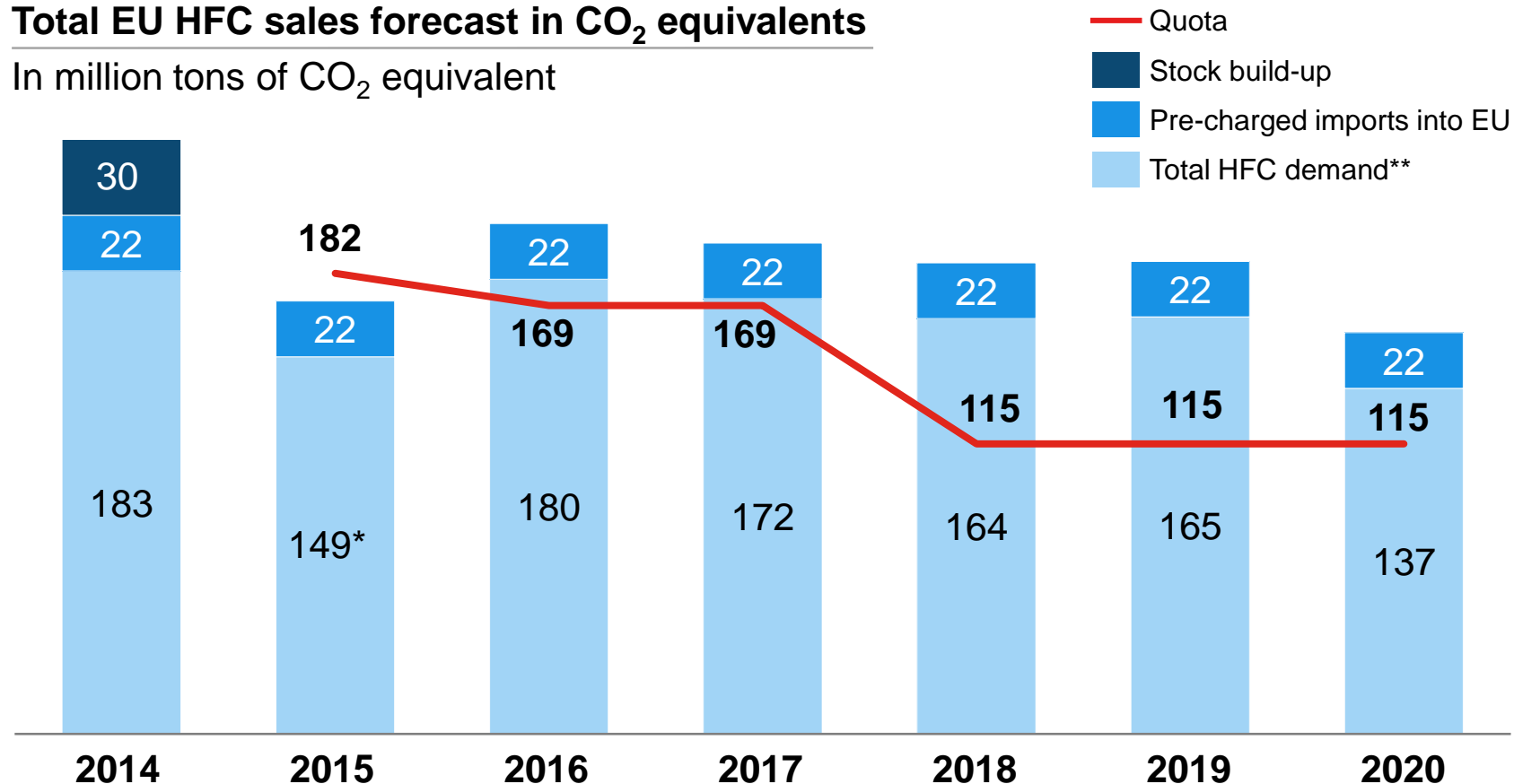
Technical Manager EMEA

Honeywell

EU28 HFC Demand – Supply forecast

Total EU HFC sales forecast in CO₂ equivalents

In million tons of CO₂ equivalent



* Adjusted for inventory being built up in 2014

** Also includes non reported HFCs

Source: HONEYWELL analysis, EEA technical report on fluorinated greenhouse gases

Need low GWP refrigerants transition before 2018!

Global GWP < 150 Regulations (Stationary & Comm. Ref.)

Country/ Region	Application	Max GWP (AR5)	Effective Date
EU (F-Gas)	Commercial Refrigerators and Freezers (Hermetically sealed)	150	2022
	Domestic Refrigerators and Freezers	150	2015
	Centralized Refrigeration systems with Capacity more than 40kW (Exception for primary circuit of cascade systems <1500)	150	2022
	Movable Room Air Conditioners	150	2020
US (SNAP)	Household Refrigerators and Freezers (proposed)	150	2021
CA (CARB)	Domestic Refrigerators (proposed)	150	2021
	Non Residential refrigeration Systems (proposed)	150	2020
Canada	Domestic Refrigerators (proposed)	150	2025
Japan (METI)	Cold Storage Warehouses > 50,000 m ³	100	2019

Introduction To Solstice[®] Family

Solstice[®] Low GWP Refrigerants:
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Solstice [®] HFO molecules Low and medium pressure applications			
	Nonflammable (ASHRAE A1)	Mildly flammable (ASHRAE A2L)	Examples of potential applications
R-134a GWP=1430	<div style="border: 2px dashed green; padding: 5px;"> Solstice[®] yf GWP* < 1 Solstice[®] ze GWP* < 1 </div>		Auto A/C, Vending, Refrigerators
			Chillers, CO ₂ Cascades Refrigerators
R-123 GWP= 77	<div style="border: 2px dashed green; padding: 5px;"> Solstice[®] zd GWP* =1 </div>		Centrifugal Chillers

Today

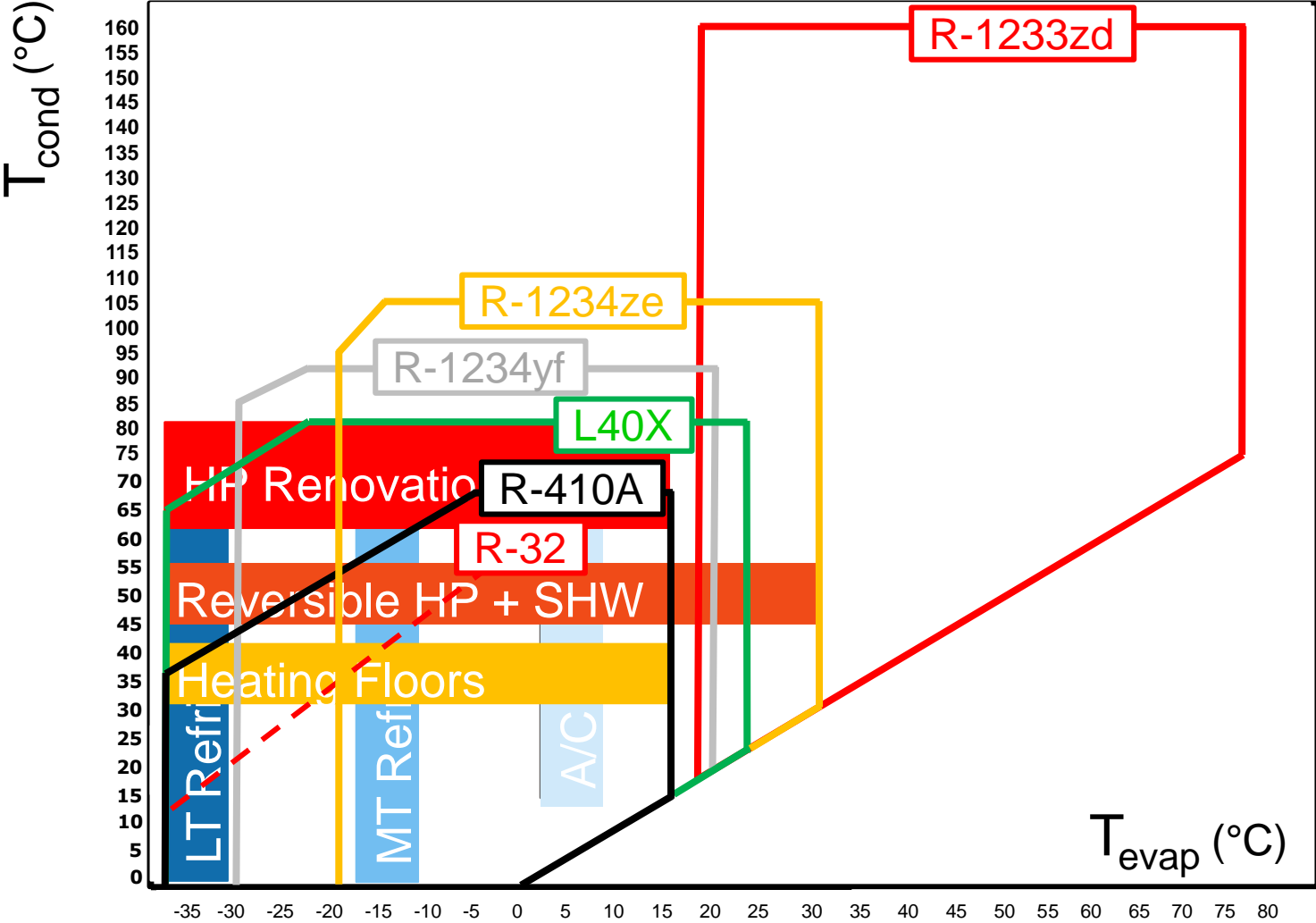


Solstice [®] Blends			
	Non Flammable (ASHRAE A1)	Mildly Flammable (ASHRAE A2L)	Examples of potential applications
R-134a GWP=1430	<div style="border: 2px dashed green; padding: 5px;"> Solstice[®] N13 (R-450A) GWP* = 547 Solstice[®] N40 (R-448A) GWP* = 1273 </div>		Chillers, Med-temp Refrigeration
R-404A GWP=3922			<div style="border: 2px dashed green; padding: 5px;"> Solstice[®] L40X (R-455A) GWP* < 150 </div>
R-22 GWP=1810	<div style="border: 2px dashed green; padding: 5px;"> Solstice[®] N20 GWP* = 203 </div>	<div style="border: 2px dashed red; padding: 5px;"> Solstice[®] L20 (R-444B) GWP* = 295 </div>	Stationary A/C, Refrigeration
R-410A GWP=2088		<div style="border: 2px dashed red; padding: 5px;"> Solstice[®] L41y (R-452B) GWP* = 676 </div>	Stationary A/C Applications

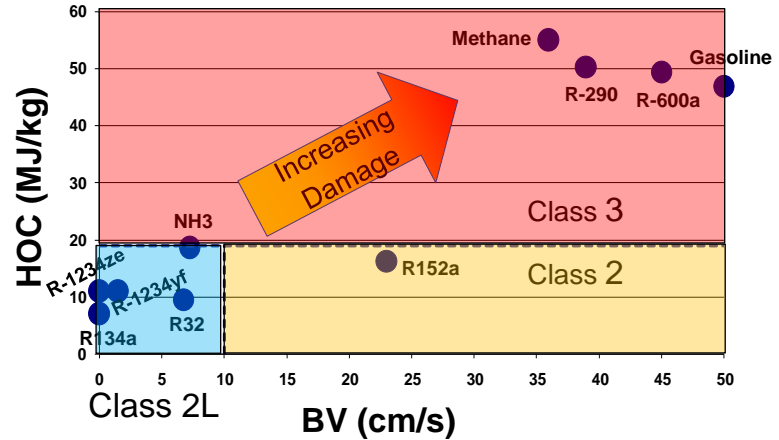
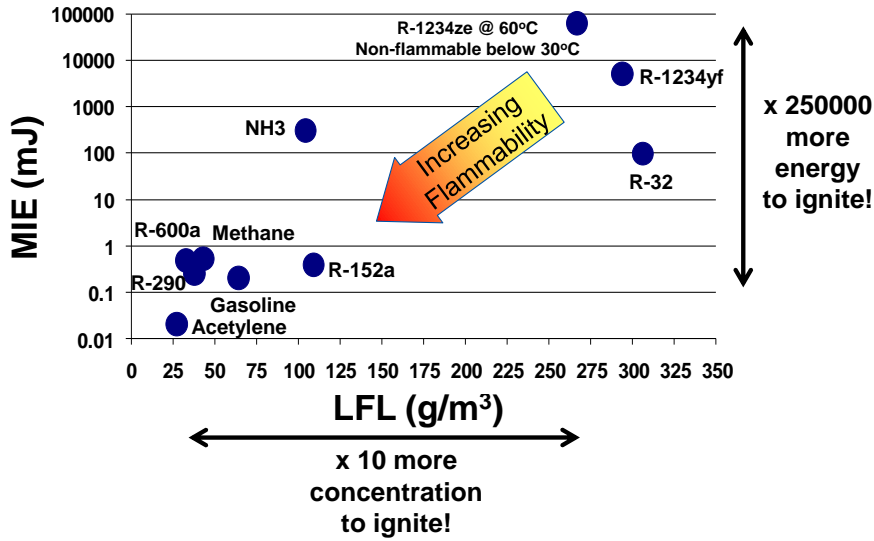
Coming soon

*IPPC5

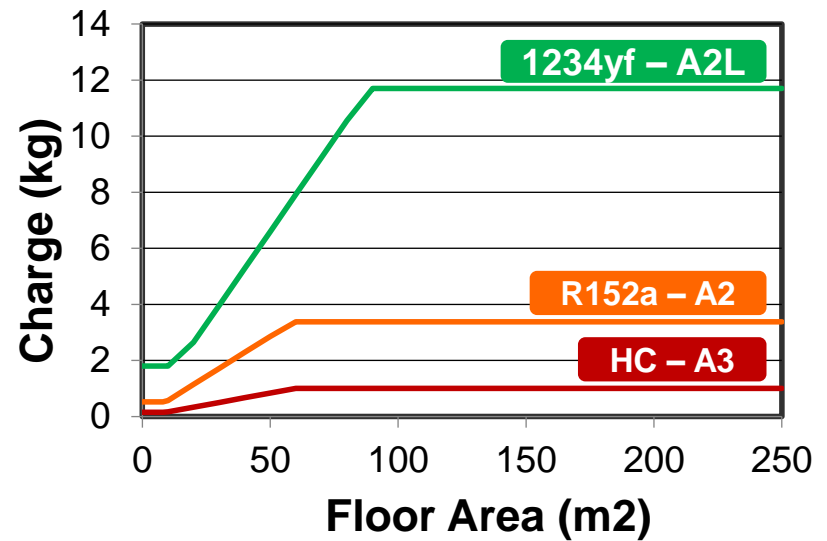
MAP Overview



EN378 Voted Positive / A2L Adoption



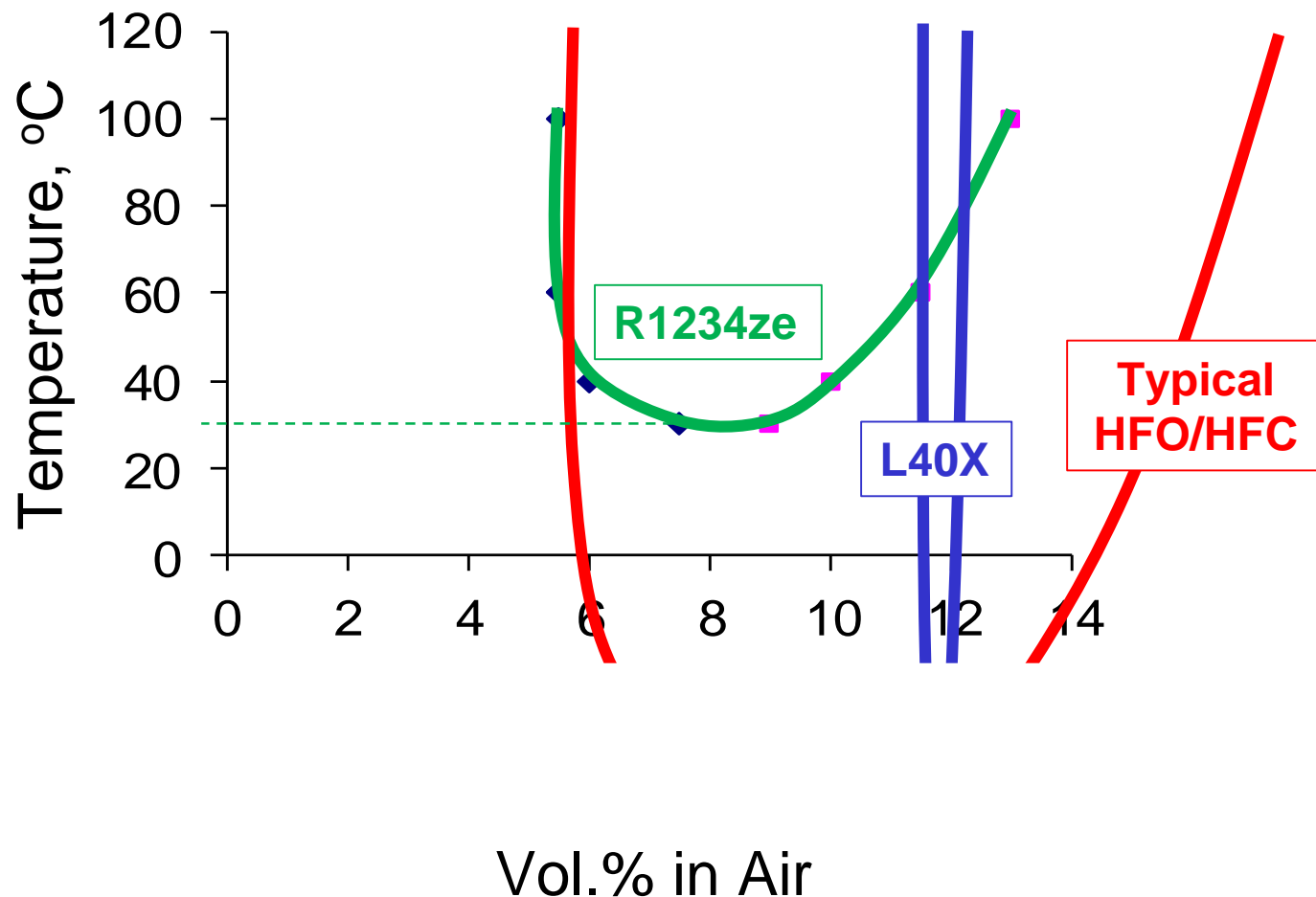
- EN378 voted mid-August 2016 with publication before end 2016
- R1234ze PED Category 2
- Increased charge for A2L!



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60kg/circuit possible with added mitigations

A2L: Yes, But...



HFO Penetration In A/C : R1234ze Is On Its Way

R134a replaced by R1234ze: A2L, GWP<1 / long term

R-1234ze Chillers

- Carrier Aqua Force Screw Chillers
- Danfoss Turbocor compressor for 1234ze
- Friotherm District Heating/Cooling
- Mitsubishi Heavy Industries
- Geoclima Screw and Centrifugal
- Star Refrigeration high efficiency Turbocor
- Airedale chillers with free cooling
- Cofely Turbocor Chiller
- Cooltherm Chillers
- Smardt Chillers
- Blue Box



Comm Ref: Solstice[®] L40X To Replace R404A

Solstice[®] L40X

GWP < 150

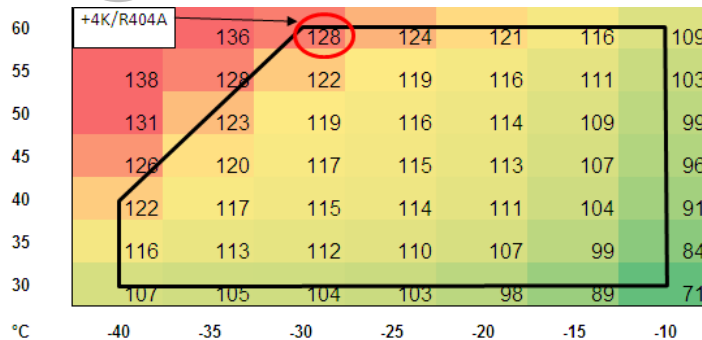
	Solstice [®] L40X
Baseline	R-404A (A1, 3922 / 3943)
GWP 4 th / 5 th	148 / 145
Class	A2L
Potential app. Use	Self-contained, condensing units New
Drop-in ⁽¹⁾ Cap.	4% lower
Drop-in ⁽¹⁾ Eff.	3% to 6 % higher
Compressor ⁽²⁾	Recip, Rotary, Scroll
Comments	Same Tdis in LT
Status	Developmental

1 Drop-in results (freezer)

	T _{evap}	T _{disch}	T _{cond}	Q ₀	COP
	[°C]	[°C]	[°C]	[%]	[%]
R404A	-34.9	100	33.5	100%	100%
L40X	-34.4	108	36.1	96%	106%



2 Calorimeter tests on compressor (FH2511Z Mid/Mid with SH=10K)



Tdischarge (°C)



	-40	-35	-30	-25	-20	-15	-10
30	-1%	2%	5%	7%	9%	11%	12%
35	-1%	3%	6%	8%	10%	11%	12%
40	-1%	3%	7%	9%	11%	12%	13%
45		2%	7%	10%	12%	14%	15%
50		0%	6%	11%	14%	15%	17%
55			4%	10%	15%	18%	19%
60			1%	9%	16%	20%	23%

COP vs. R404A

Comm Ref: Solstice[®] L40X to replace R404A

Solstice[®]L40X

GWP<150

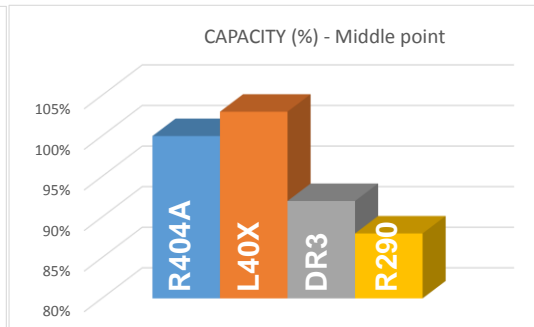
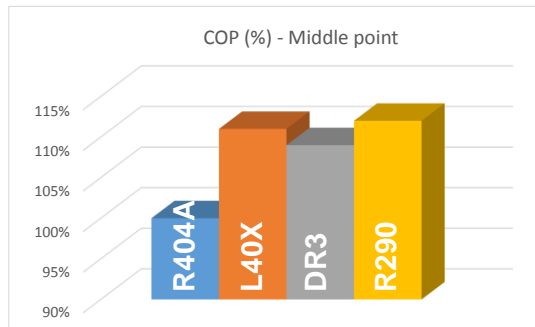


NEK2134GK

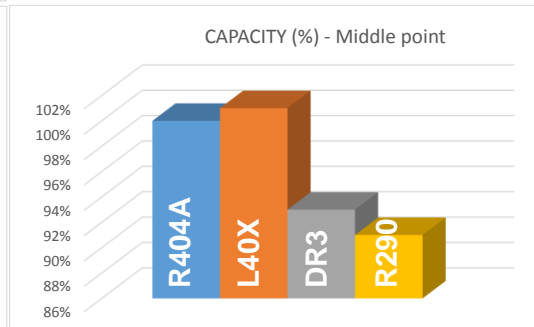
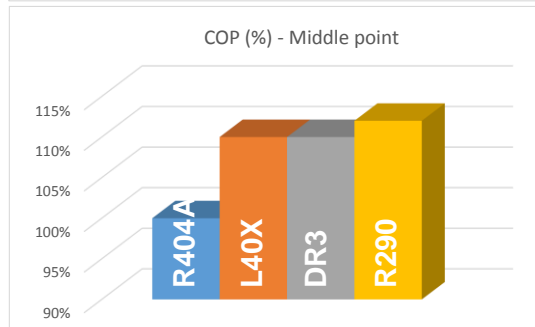
embraco POWER IN. CHANGE ON.

SH=11.1C for R404A, L40X and DR3
SH=22.2C for R290
(SH>20C needed for reliability)

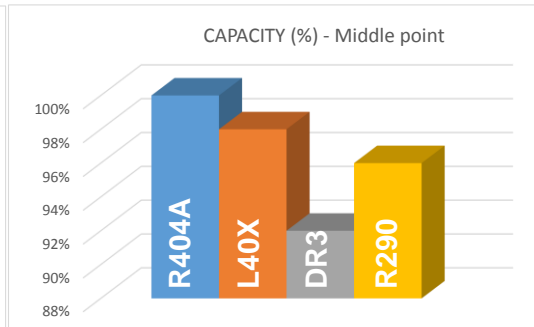
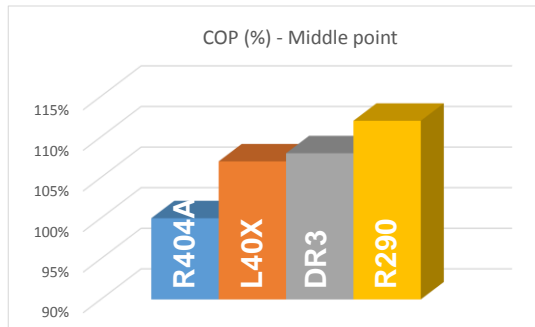
-10/45C (SC0)



-20/45C (SC0)



-30/45C (SC0)

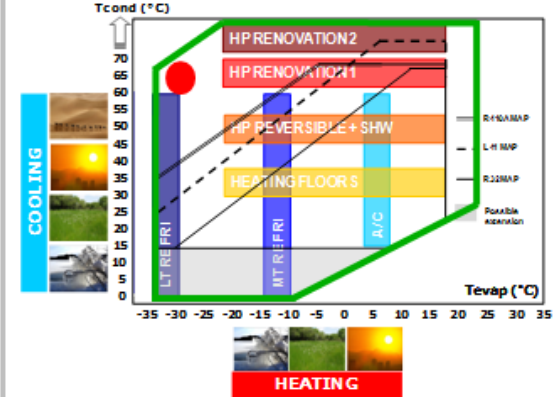
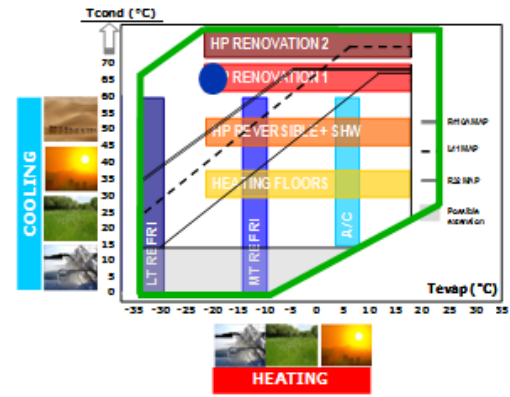
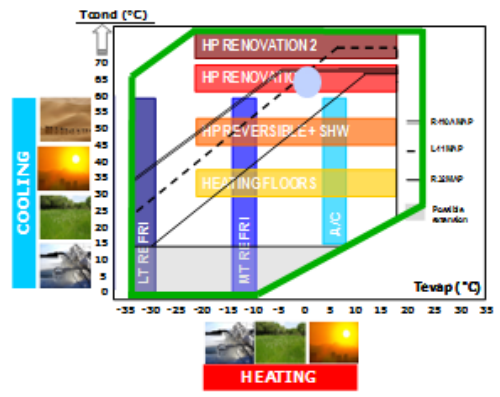


R410A Replacement: More Than 1 Scenario...

A/C mode
● 0/65C

Process chiller
● -20/65C

HP mode
● -30/65C



	R410A	R32	L41y or L41z	L40X		R410A	R32	L41y or L41z	L40X		R410A	R32	L41y or L41z	L40X
GWP	☹️	😊	😊	😊	GWP	☹️	☠️	😊	😊	GWP	☠️	☠️	☠️	😊
Tdischarge	😊	😊	😊	😊	Tdischarge	😊	☠️	☹️	😊	Tdischarge	☠️	☠️	☠️	😊
COP	😊	😊	😊	😊	COP	☹️	☠️	☹️	😊	COP	☠️	☠️	☠️	😊
Glide ≈0	😊	0	+	++	Glide ≈0	😊	☠️	+	++	Glide	☠️	☠️	☠️	++

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Solstice[®] L40X could cover all applications

Conclusions

- Several HFO based solutions are available to transition to ultra-low GWP world ('regulation proof' vision) while increasing safety baseline (A2L vs. A3).
- Solstice[®] L40X should be seen as a new opportunity to replace not only R22/R407C/R404A/R290 but also R410A/R32 in the long term as ODP=0, GWP<150, A2L and no injection needed for high temp/pressure ratio. It will also give a performance advantage in high ambient climates.
- With a very high LFL (11.8%) and a very small flammability range (1.1%), L40X will help increasing safety level of installation vs. other A2L or A3 in the same capacity range.