Tunca Sekban,
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LOW GWP REFRIGERANT SOLUTIONS FOR HEAT PUMP APPLICATIONS

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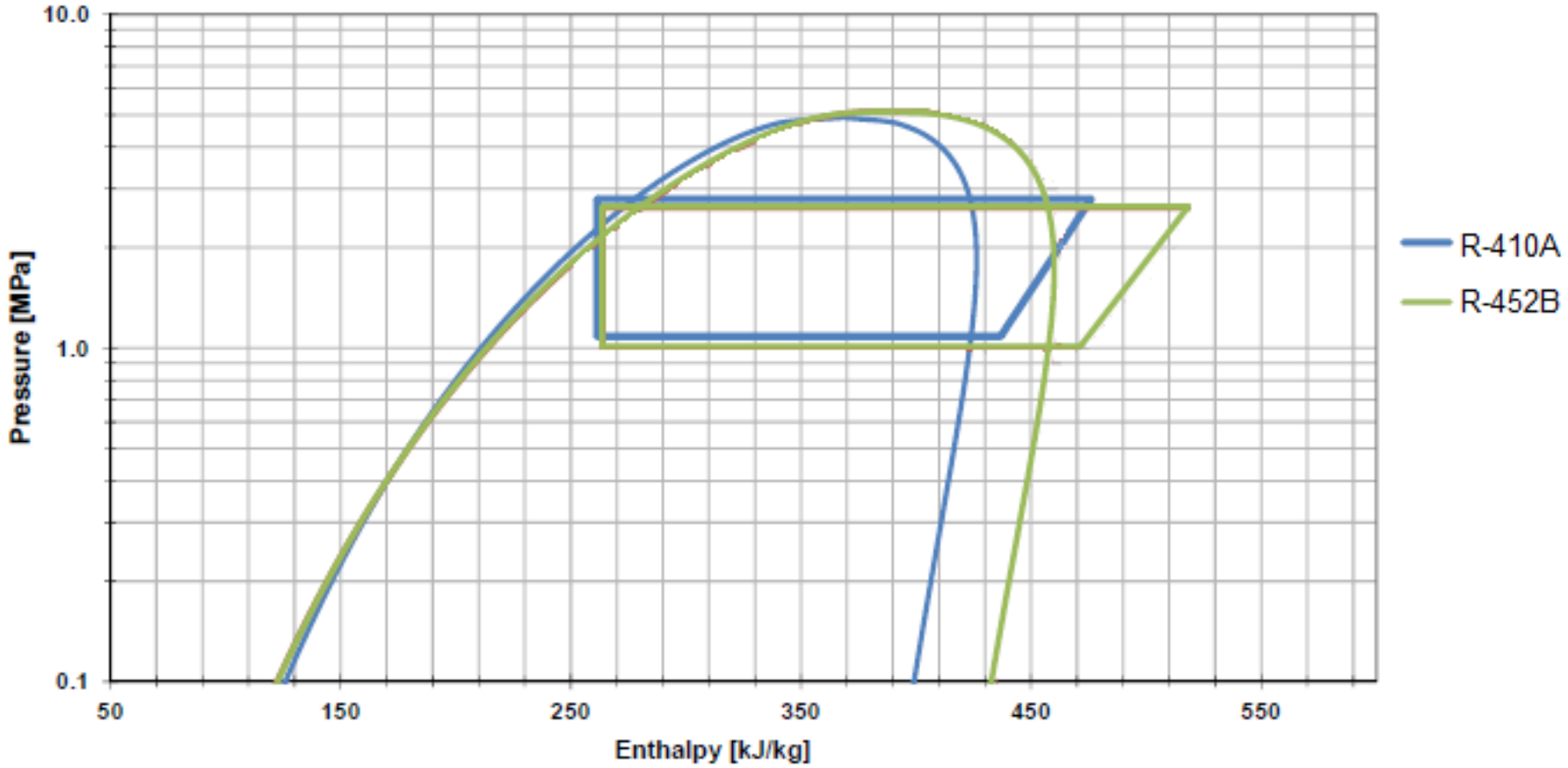
Solstice® Stationary Platform (Short Term <750 GWP) Heat Pumps

Application	Market Solution	HON Interim Solution	Refrigerant Choice Requirements	System Image
Heat Pump Tumble Dryers	**R-134a** GWP = 1430	**Solstice® N13 (R-450A)** GWP = 604	Low GWP Low design and refrigerant cost Matching capacity and efficiency	
Heat Pumps Water Heaters	**R-134a** GWP = 1430	**Solstice® N13 (R-450A)** GWP = 604	Low GWP Low design and refrigerant cost Matching capacity and efficiency	
Heat Pumps Space Heaters	**R-410A** GWP = 2088	**Solstice® L41y (R-452B)** GWP = 698	Low GWP Low design and refrigerant cost Matching capacity and efficiency	
	R-407C GWP = 1774	**N/A**		

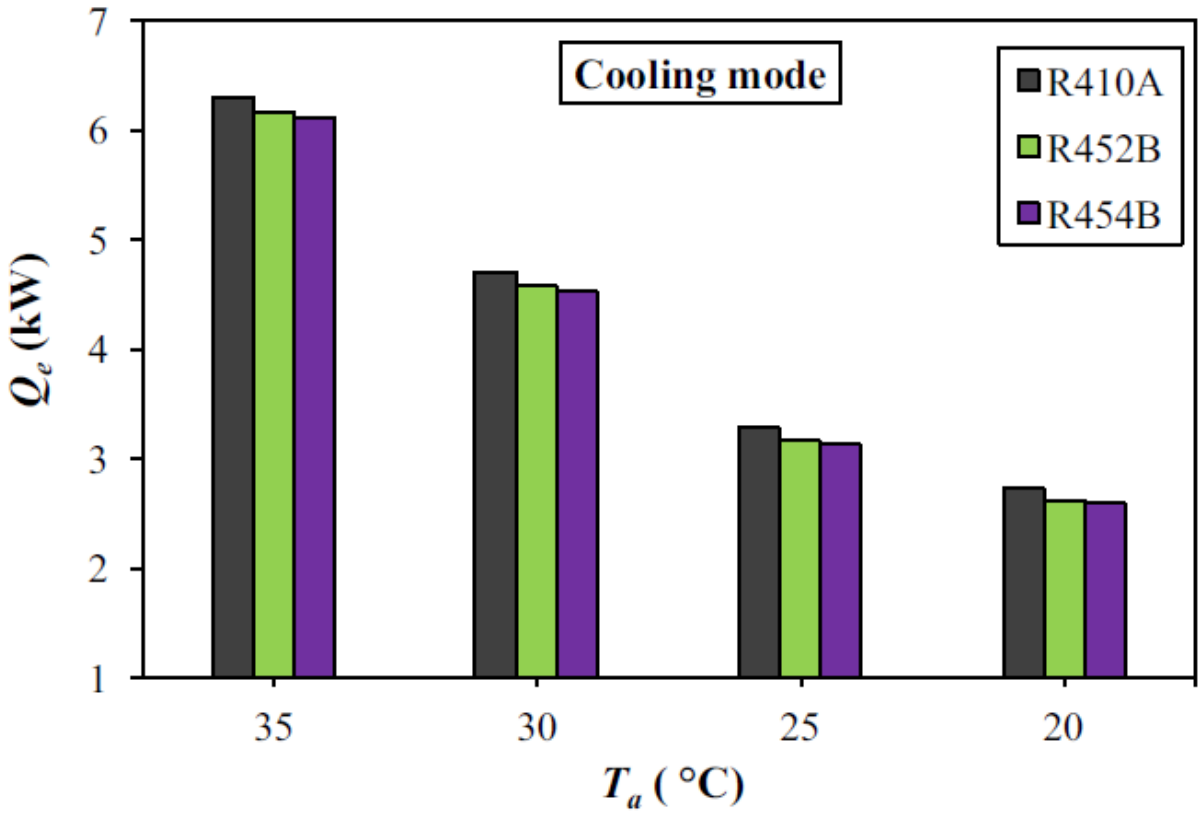
Solstice® L41y Thermodynamic Properties

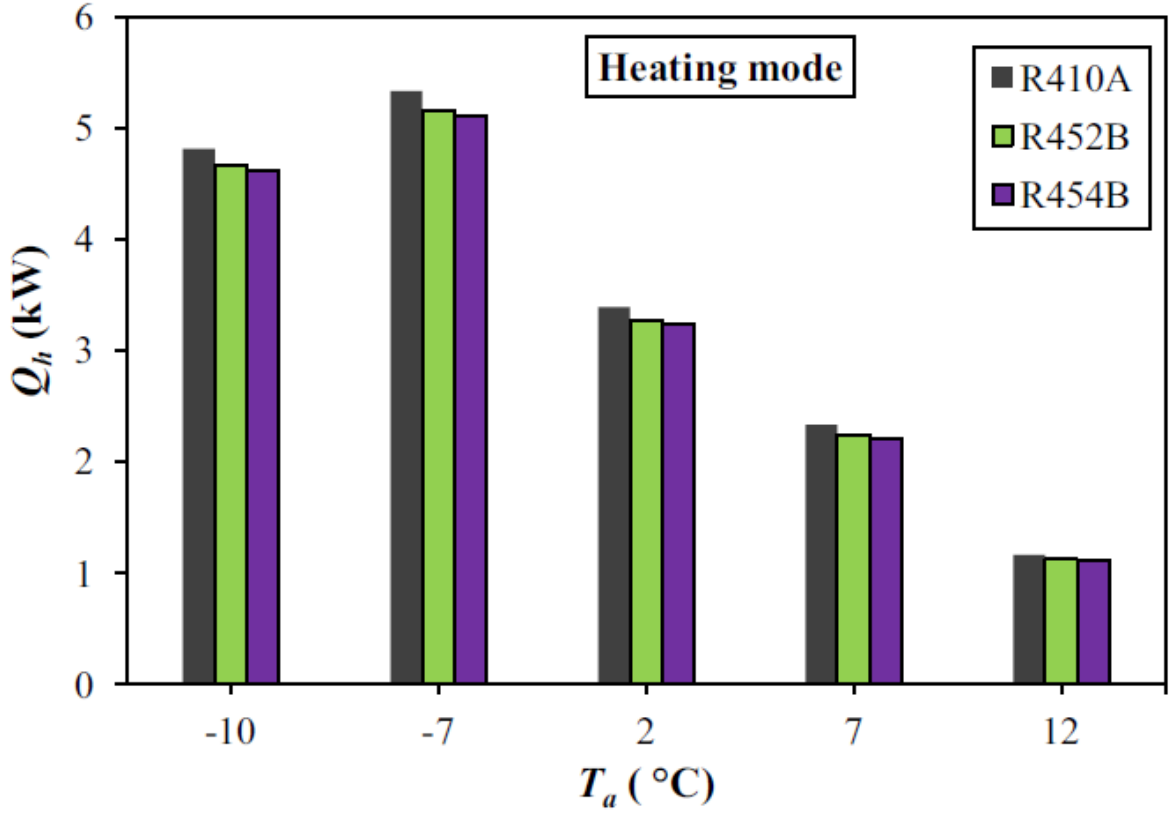
- L41y is a zeotropic blend comprised of three components R-32 (67%), R-1234yf (26%) and R-125 (7%)
- L41y has similar design pressure characteristics as R-410A that makes it an ideal replacement solution



Solstice® L41y Thermodynamic Properties - Capacity

- L41y achieves the closest capacity to R-410A both in cooling and heating operating conditions which makes L41y the most suitable candidate to replace R-410A in medium term.
- Thanks to capacity match, L41y does not require significant re-design from existing R-410A equipment.





*Seasonal performance assessment of refrigerants with low GWP as substitutes for R410A in heat pump air-conditioning devices, Applied Thermal Engineering 125 (2017) 401-411

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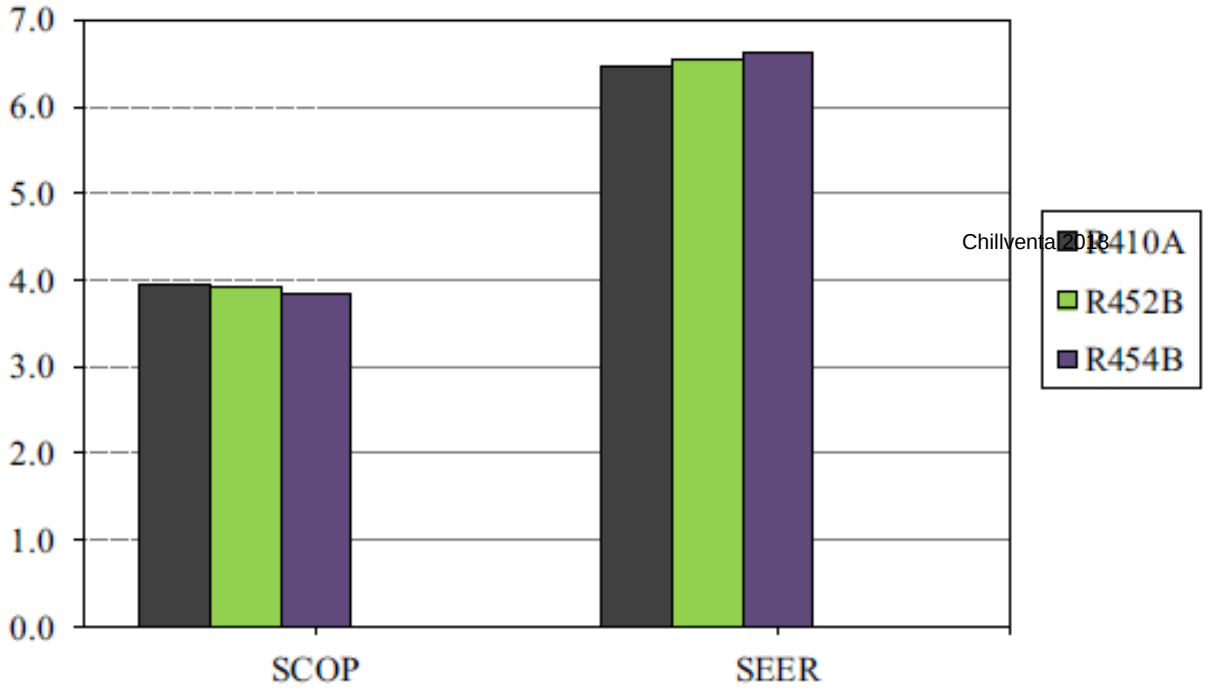
Solstice® L41y Thermodynamic Properties - Efficiency

- L41y efficiency matches R410A equipment efficiency both in heating and cooling operations



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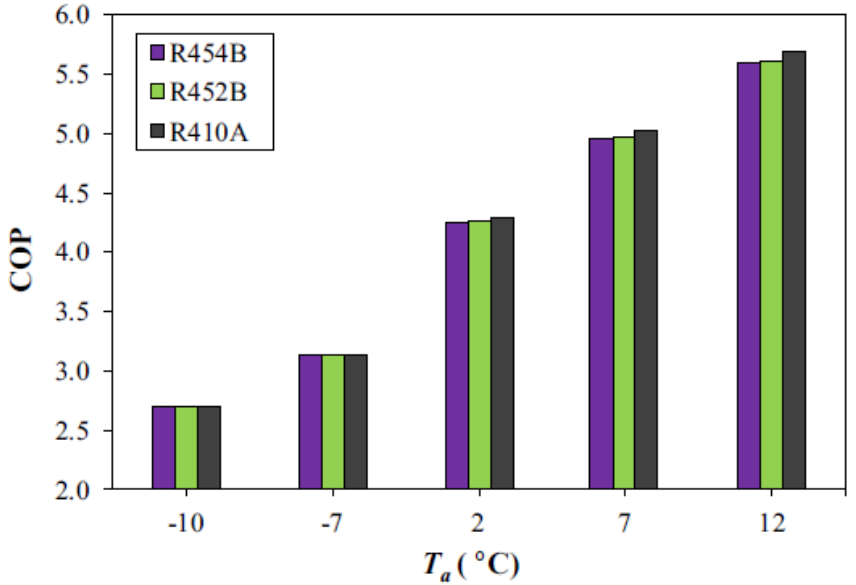

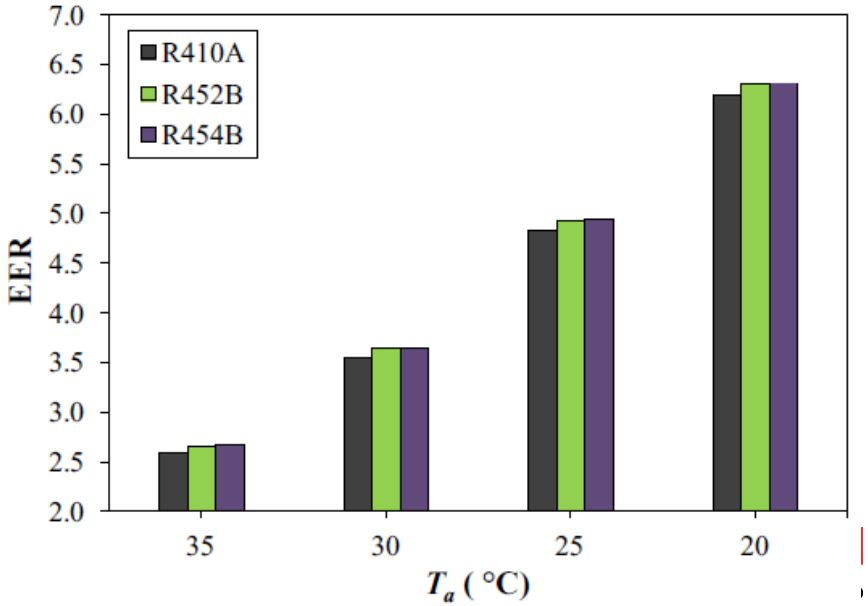

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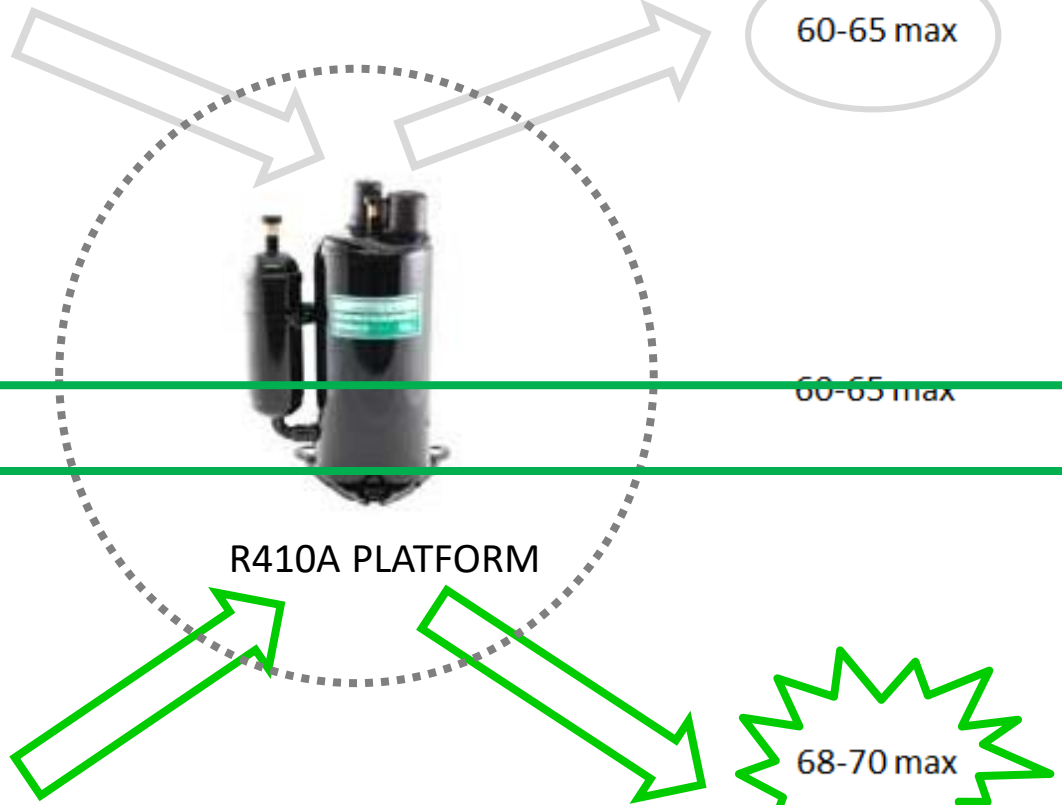
Solstice® L41y Additional Benefit in Heating Mode

	Tcritical (deg C)	Pcritical (bar)	GWP (AR5)
R410A	71.3 ☹	49 ☺	1923 ☹
R32	78.1 ☺	57.8 😐	677 😐
L41y	79.6 ☺	54.5 😐	676 😐



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L41y vs. R-410A Design Optimizations

Capacity:

For the similar operating conditions, the capacity of L41y matches R-410A capacity and is even better in high ambient regions. Therefore, no dimensional modifications are required to the equipment design.

Efficiency:

L41y has a better overall efficiency than R-410A which provides cost savings for end-users and it helps equipment manufacturers to comply with the EcoDesign requirements.

Discharge Temperature:

The discharge temperature of L41y is approx. 5% higher than R-410A which is well below compressor discharge temperature limit. Therefore it saves potential mitigation cost and improves compressor longevity.

Discharge Pressure:

The discharge pressure of L41y is equivalent to R-410A and is 7% lower. No design modifications are required for existing heat exchangers.

Refrigerant Charge:

The mass flow and refrigerant charge of L41y is 20% and 8% lower than R410A, respectively. This helps in pressure drop reduction and improve heat exchanger efficiency.

For the L41y equipment, there is no need for any modifications to the equipment, piping and valve design.

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Material & Oil Compatibility:

Since L41y is a blend of the same constituents as R-410A, therefore L41y exhibits similar behaviour with existing lubricants as R-410A and is compatible with the same POE grades as R410A is.

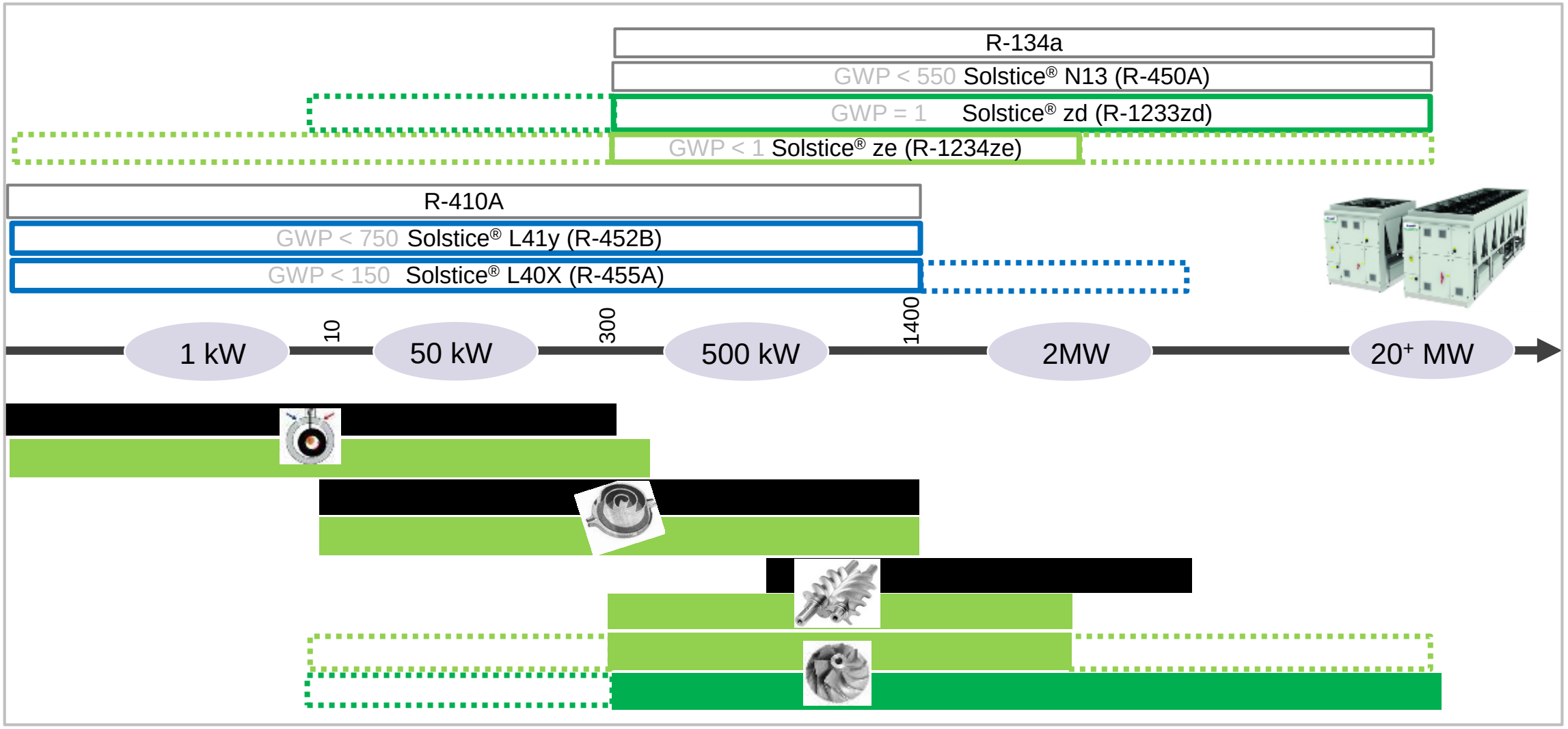
This means, no need to check the compatibility with other oil grades.

Flammability:

L41y's lower burning velocity (3 cm/s) mitigates the flame propagation due to pressure rise.

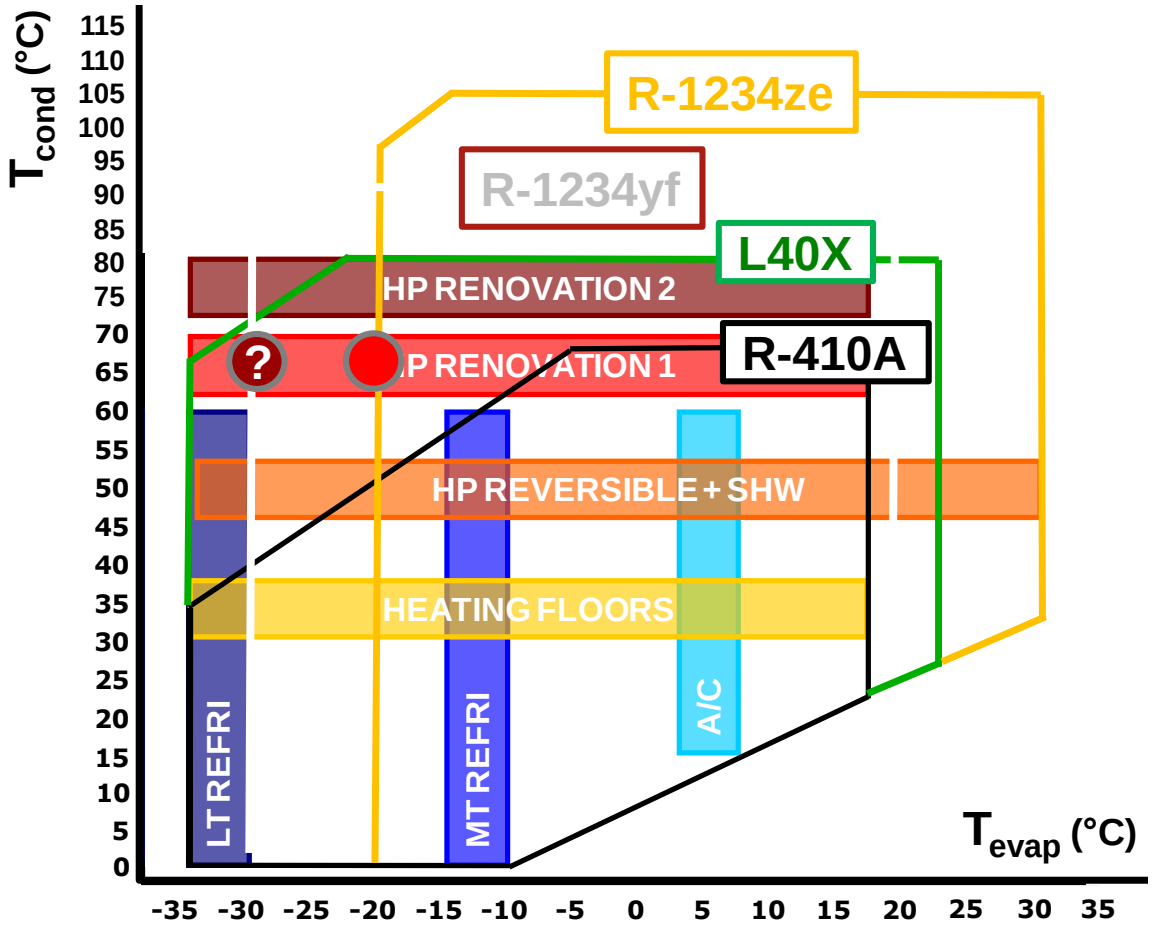
Due to the low MIE of L41y, sparks from light switches and contactors in residential buildings would not create enough energy to ignite a flame.

Comfort A/C: Future Technology Projection



COMPRESSOR SPECS: AIR/WATER HEAT PUMP

Current Refrigerants: R410A / R407C ⇨ Future Refrigerants: R290 / R455A



- HP: mainly A/W, mostly reversible but with heating mode optimized (cooling is only a plus)
- R455A is PED group1

Refrigerant: R455A

Capacity range ≈ 3 to 10kW

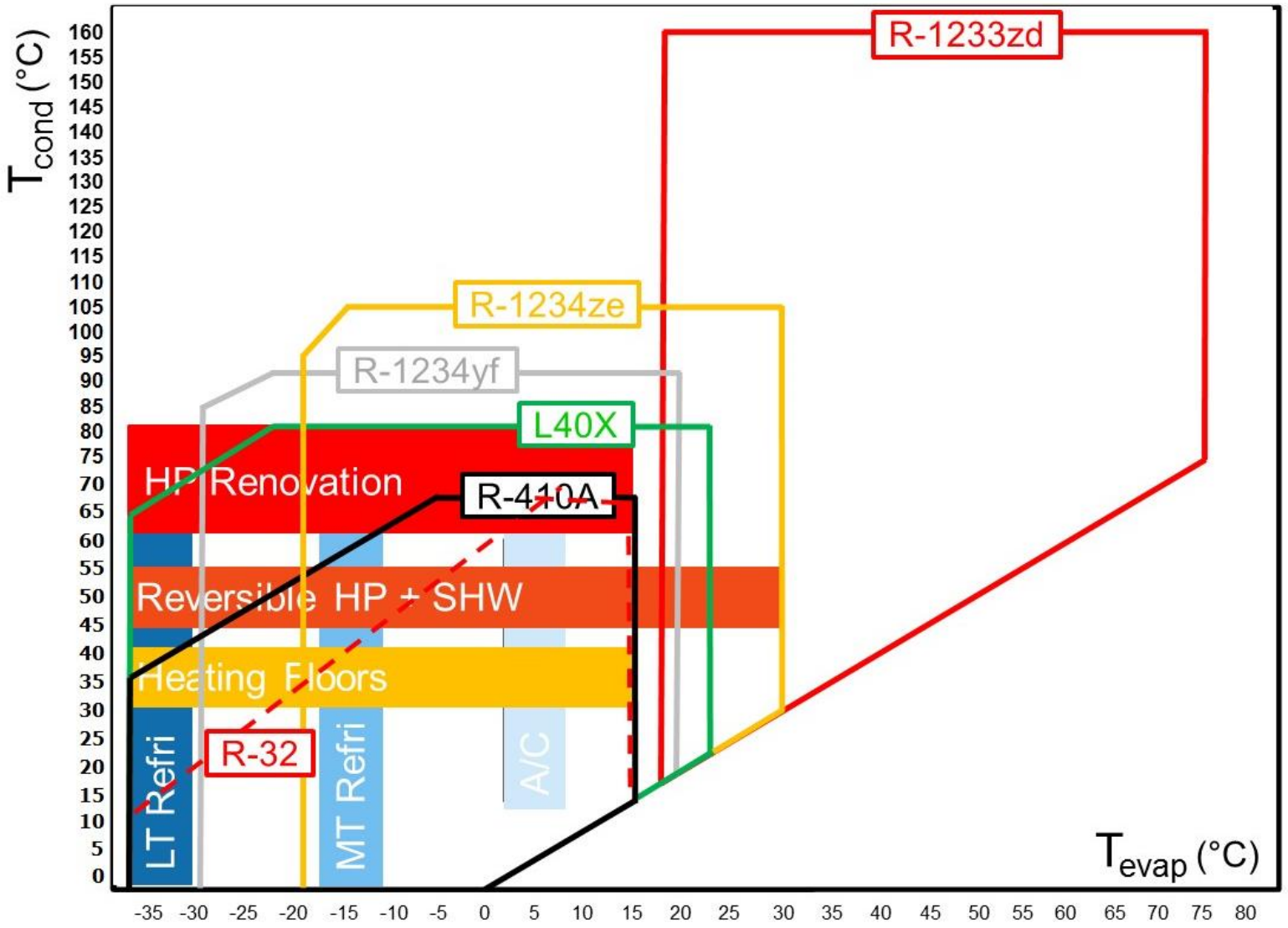
Operating MAP: as large as possible (minimum -20/65C)

Efficiency: similar to R290

HP mode -20/65C

	R410A	R32	R455A	R1234yf
GWP	☹	😐	☺	☺
Tdisch	☹	☠	☺	☺
COP	☹	😐	☺	☺
$/kW	☺	☺	😐	☹

Solstice® L40X Extends Operating Map



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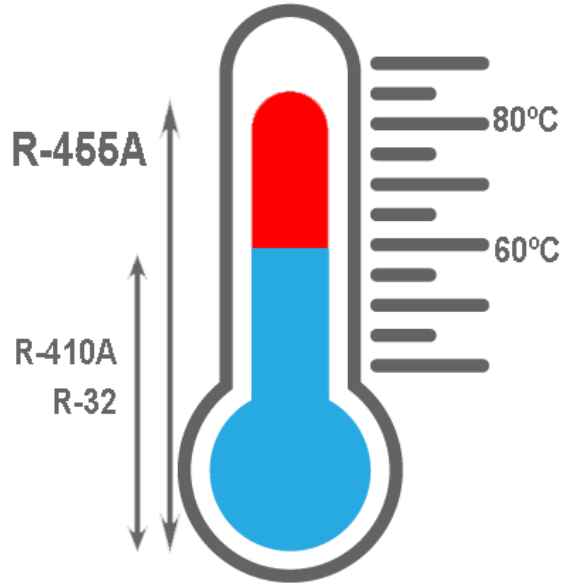
R-410A Platform



Solstice® L40X can provide higher water temperature

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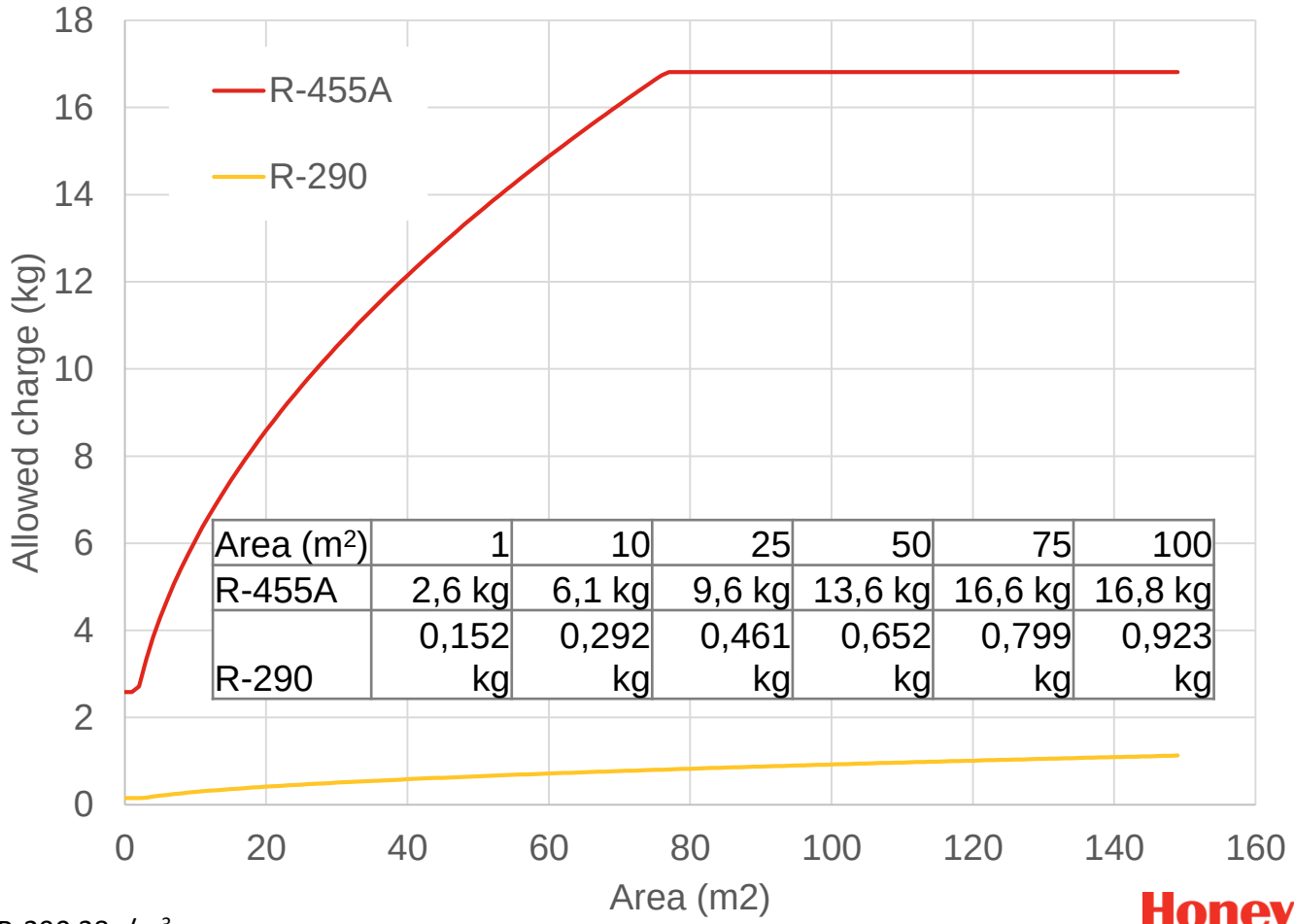
SIMULATION: Main Parameters

	Fluid	GWP	Compressor: ΔTdisch	Compressor: Pdischarge	Compressor: Compression Ratio	HX: Evaporator Glide	HX: Condenser Glide
			°C	kPa		°C	°C
0/65C SH5/SC3	R410A	2088	BASE	4279	5,4	0,1	0,1
	R32	675	30	4384	5,4	0,0	0,0
	R407C	1774	-8	2963	6,1	3,4	3,7
	L40X (R455A)	148	-13	3048	5,9	4,7	6,8
	R1234yf	<1	-36	1835	5.8	0,0	0,0
	R1234ze	<1	-32	1436	6.6	0,0	0,0
-20/65 SH5/SC3	R410A	2088	BASE	4279	10,7	0,0	0,1
	R32	675	53	4384	10,8	0,0	0,0
	R407C	1774	-12	2963	13,0	3,0	3,7
	L40X (R455A)	148	-24	3048	12,2	3,8	6,8
	R1234yf	<1	-57	1835	12,2	0,0	0,0
	R1234ze	<1	-49	1436	14,8	0,0	0,0
-30/65C SH5/SC3	R410A	2088	BASE	4279	15,9	0,0	0,1
	R32	675	68	4384	16,0	0,0	0,0
	R407C	1774	-16	2963	20,0	2,9	3,7
	L40X (R455A)	148	-32	3048	18,5	3,4	6,8
	R1234yf	<1	-72	1835	18,5	0,0	0,0
	R1234ze	<1	-60	1436	23,5	0,0	0,0

Charge limits for heatpumps - standard systems

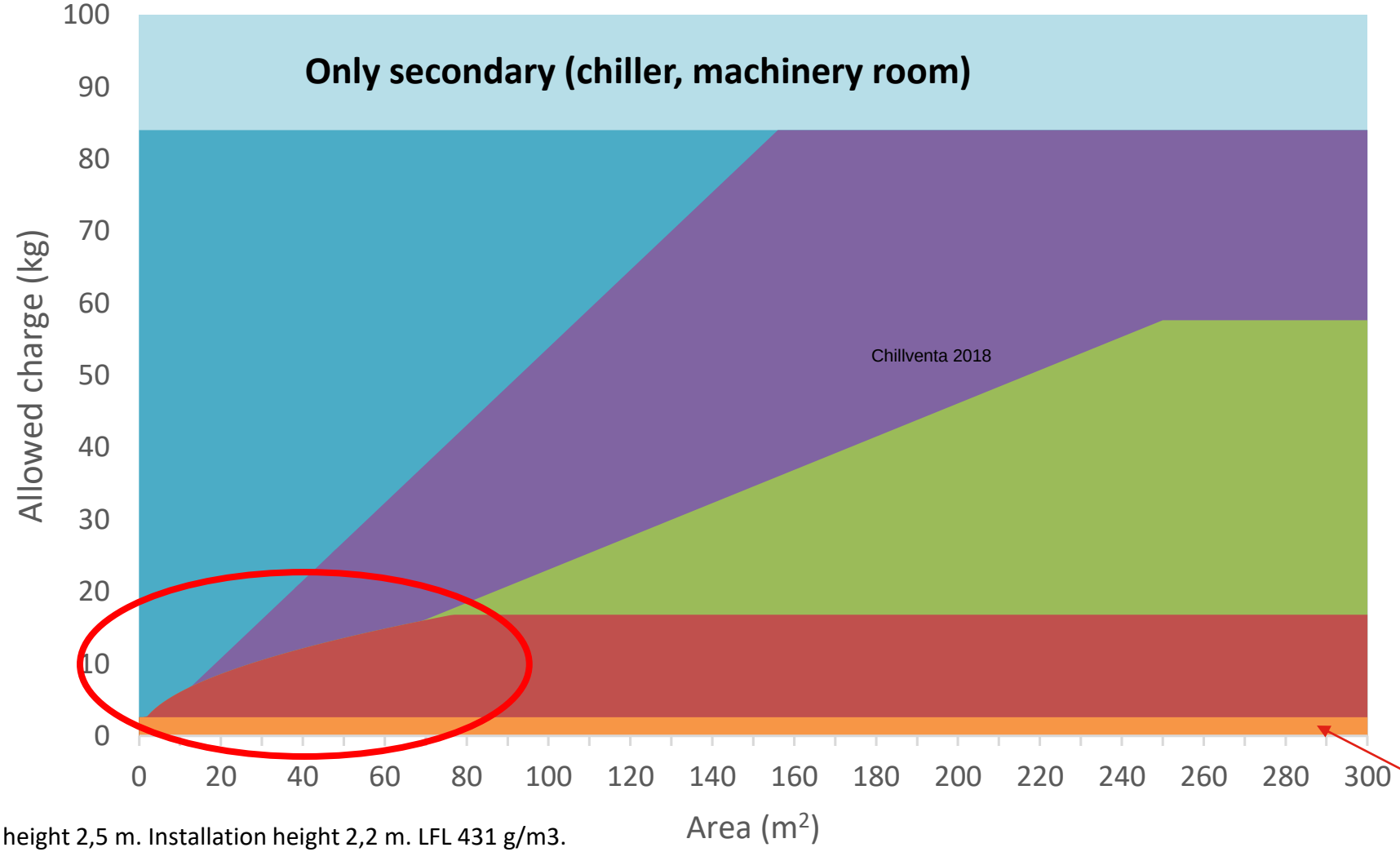
A2L (e.g. R-455A) and A3 (e.g. R-290/propane) have very different maximum allowed charge sizes, aiming for two different parts of the market



Area (m^2)	1	10	25	50	75	100
R-455A	2,6 kg	6,1 kg	9,6 kg	13,6 kg	16,6 kg	16,8 kg
R-290	0,152 kg	0,292 kg	0,461 kg	0,652 kg	0,799 kg	0,923 kg

Room height 2,5 m. Installation height 2,2 m. LFL for R-455A 431 g/m^3. LFL for R-290 38g/m^3.

R-455A (A2L) charge limits in heatpumps



84,0 kg

57,7 kg

16,8 kg

2,6 kg

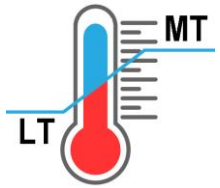
No room size requirements below 2,6 kg

Room height 2,5 m. Installation height 2,2 m. LFL 431 g/m3.

Solstice L40X: Summary

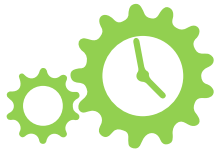
BENEFITS

No tax, no ban, min quota*



MT and LT

Larger charge than HC **



Higher efficiency

APPLICATIONS

- Heat pumps
- Plug-ins
- Condensing units

USE

Testing at major components OEM's.
Operates within requirements / limits.

"Near" drop-in: meets key needs of capacity, Tdis, pressure ratio

*F-gas: GWP<150 for hermetically sealed systems by 2022
Only the HFC part needs to be accounted
** Some changes required to manage A2L

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