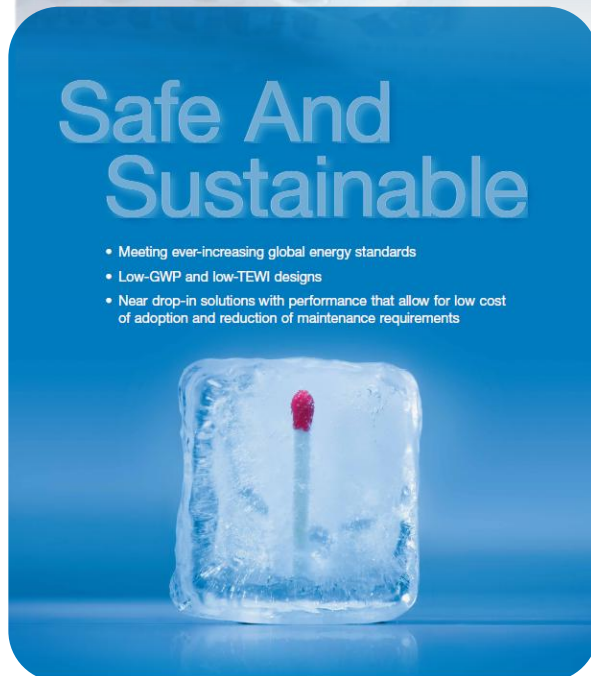


Honeywell Refrigerant Update

Honeywell

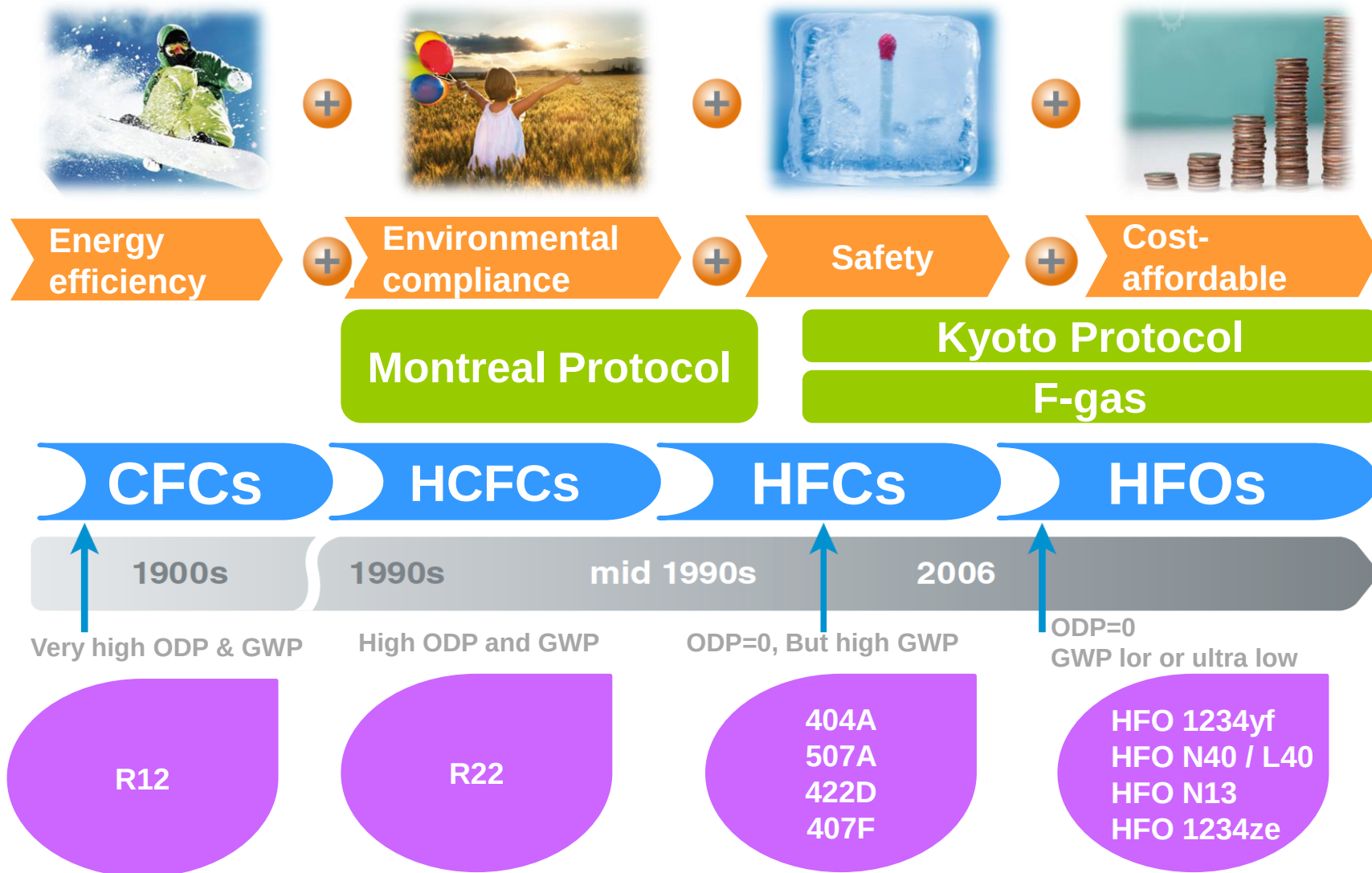
Honeywell's refrigerants key attributes

Honeywell



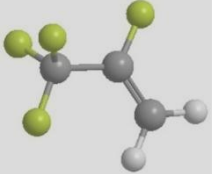
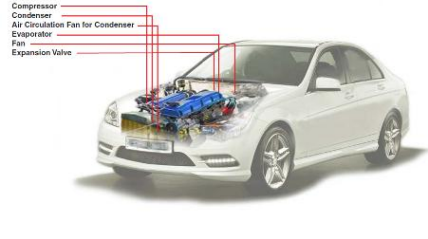
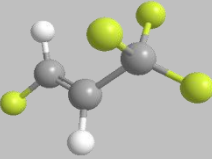
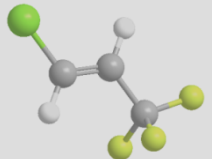
Fluorine Products – A history of innovation

Honeywell



Solstice™ Low Global Warming Platform

Honeywell

Molecules	Applications	Status
 Solstice™ MAC	 Mobile Air Conditioning	- Commercialised globally at major Auto OEM's - Honeywell OEM After -Market operations delivering product globally
 Solstice™ GBA / Propellant	 Extruded Polystyrene (XPS)  Aerosol Propellant	- Commercialised in broad range of applications globally - Large volume plant under construction; startup in early 2014
 Solstice™ LBA / Performance Fluid	 Appliances  Spray Foam  Precision Cleaning	- Customer adoption in several Foam Applications - Excellent performance in Precision Cleaning Applications - Large volume plant under construction; start-up in early 2014
Solstice™ N & L Series Blends	 Commercial Chillers  Commercial Refrigeration  Residential Air-Conditioning	- Commercialised in Chiller Applications. - Broad range of products developed for all major applications - Significant engagement from major global OEM's

Solstice™ Liquid Blowing Agent (LBA)

Honeywell

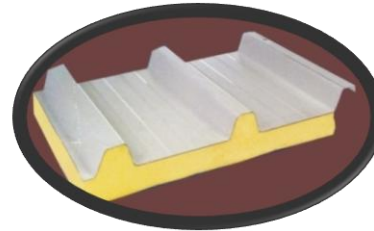
- **Broad Applications:**
Appliance, Spray Foam, Panel, Cold Storage, Reefers
- **Numerous Successful Trials,**
Including in EU
- **Customers Adopting Product**
- **Commercially available:**
 - Today: Semi-commercial
 - Commercial: 2014



Appliance



Spray Foam



Panel Foam



August 15, 2012

Whirlpool Corporation and Honeywell Introduce Most Environmentally Responsible and Energy Efficient Insulation Available into U.S. Made Refrigerators

Whirlpool Corp. Leaps Ahead of Industry Standards, Committing to Use Honeywell's Solstice Liquid Blowing Agent

***High Performance, Energy Efficient
& Environmentally Friendly Foam Blowing Agent***

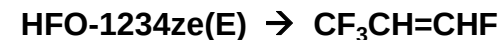
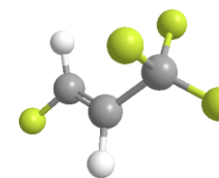
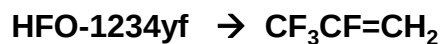
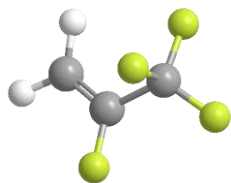
- ♦ **Honeywell Unique Offering – 3 HFO's Available Today**
 - Energy Efficiency + Environmentally Compliant
- ♦ **Commercialised**
 - Performax™ LT – The Most Energy Efficient Replacement for R22 in Commercial Refrigeration
 - ♦ 10-20% Energy Efficiency Benefit vs R404A
 - Solstice™ ze for Chillers and District Cooling
 - ♦ Working examples Waitrose UK / Scandinavia
 - Solstice™ yf for Mobile A/C
 - ♦ New cars in Europe / US switched
- ♦ **Development**
 - Solstice™ L41 for A/C
 - Solstice™ N and L Blends To Replace all R22/R404A

The Technology Leader in Energy Efficient HFO's

Solstice Range of Refrigerants

Honeywell

	Alternative To	GWP	Ashrae Class	Performance (vs alternative)	Applications	Status
Solstice™ yf HFO-1234yf	R-134a	4	A2L	Both capacity & efficiency very similar to R134a (typically +/- 5%)	MAC, buses & coaches AC, vending, fridges	Commercially available. Adopted by MAC industry. Proven records in vending units.
Solstice™ ze HFO-1234ze	R-134a	6	A2L	Efficiency comparable or better than R-134a	Chillers, vending, CO ₂ cascade systems, air dryers, heat pumps	Commercially available. Non-flammable for handling and storage. Proven records in chillers. Initial trials in cascade systems.
Solstice™ zd HFO-1233zd	R-123	<5	tbd	Better capacity & similar efficiency to highly efficient R123	Centrifugal chillers ORC, high temp applications, high capacity chillers	Available for testing.



Solstice™ LGWP Refrigerant Blends—Stationary Platform

Honeywell

Solstice™ HFO's			
Current Product	Non Flammable	Mildly Flammable (ASHRAE A2L)	Possible Application
HFC-134a GWP=1430		Solstice yf GWP = 4	Auto A/C, Vending, Refrigerators
		Solstice ze GWP = 6	Chillers, Heat Pumps, CO2 Cascades, Refrigerators
R-123 GWP= 77	Solstice zd GWP <5		Centrifugal Chillers, ORC

Solstice™ HFO Blends			
Current Product	Solstice™ N Series Reduced GWP Option Non Flammable (ASHRAE A1)	Solstice™ L Series Lowest GWP Option Mildly Flammable (ASHRAE A2L)	Possible Application
HFC-134a GWP=1430	N-13 – GWP ~600		Chillers, Med- Temp Refrigeration
HCFC-22 GWP=1810	N-20 - GWP ~1000	L-20 - GWP <350	Stationary A/C, Refrigeration
R-404A GWP=3922	N-40 - GWP~1300	L-40 - GWP~200-300	Transport Refrigeration, Low-Tem Refrigeration
R-410A GWP=2088		L-41 - GWP <600	Stationary A/C Applications



Key Customers / Partners

Europe

TESCO



KLIMA-THERM

ASDA WAL*MART Waitrose

precision
REFRIGERATION

CELLI
DISPENSING EQUIPMENT

STAR
REFRIGERATION

Capeland Scroll
Built to live up to your reputation

BITZER
INTERNATIONAL

Maneurop

North America

Carrier

TRANE

Walmart

Danfoss

McQuay
International

Johnson Controls

TURBOCOR

EMERSON
Climate Technologies

Asia

Haier

TOSHIBA

SAMSUNG

HITACHI
Inspire the Next

ACTRON AIR

temperzone

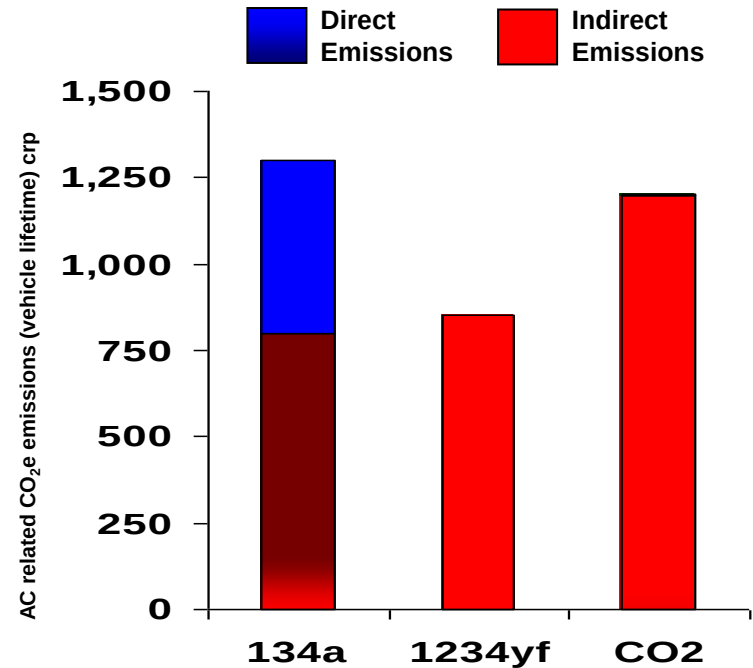
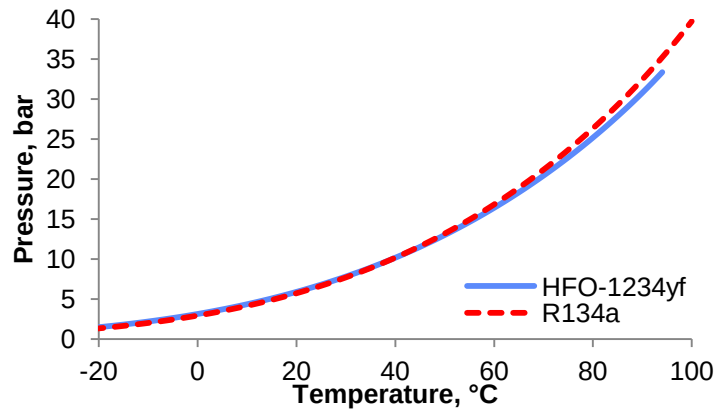
Solstice™ Offerings for Stationary Refrigeration and A/C

HONEYWELL - CONFIDENTIAL

SolsticeTM yf

Mobile Air Conditioning

Honeywell



Lowest carbon footprint of all AC Technologies

HFO-1234yf the refrigerant of choice to replace R134a in MAC.

Viable solution for buses and coaches

Honeywell

Capacity (kW) of HFO1234yf vs baseline R134a

Ambient temperature	Evaporation temperature	HFO1234yf
35°C	23°C	95 %
40°C	25°C	95 %
42°C	23°C	96 %
45°C	27°C	95 %

Discharge temperature (°C) of HFO1234yf vs baseline R134

Ambient temperature	Evaporation temperature	HFO1234yf
35°C	23°C	-9°C
40°C	25°C	-7°C
42°C	23°C	-10°C
45°C	27°C	-11°C

- Capacity matched with non-optimized system
- 11% lower discharge temperature
- 20% lower charge for Solstice yf

HISPA@LD



Viable solution for trains

Honeywell



 **merak**
Sistemas Integrados
de Climatización

- Air conditioning system for trains
- Direct emissions reduction by 99.7%
- Bench test successful. System optimization ongoing
- Field trials in preparation



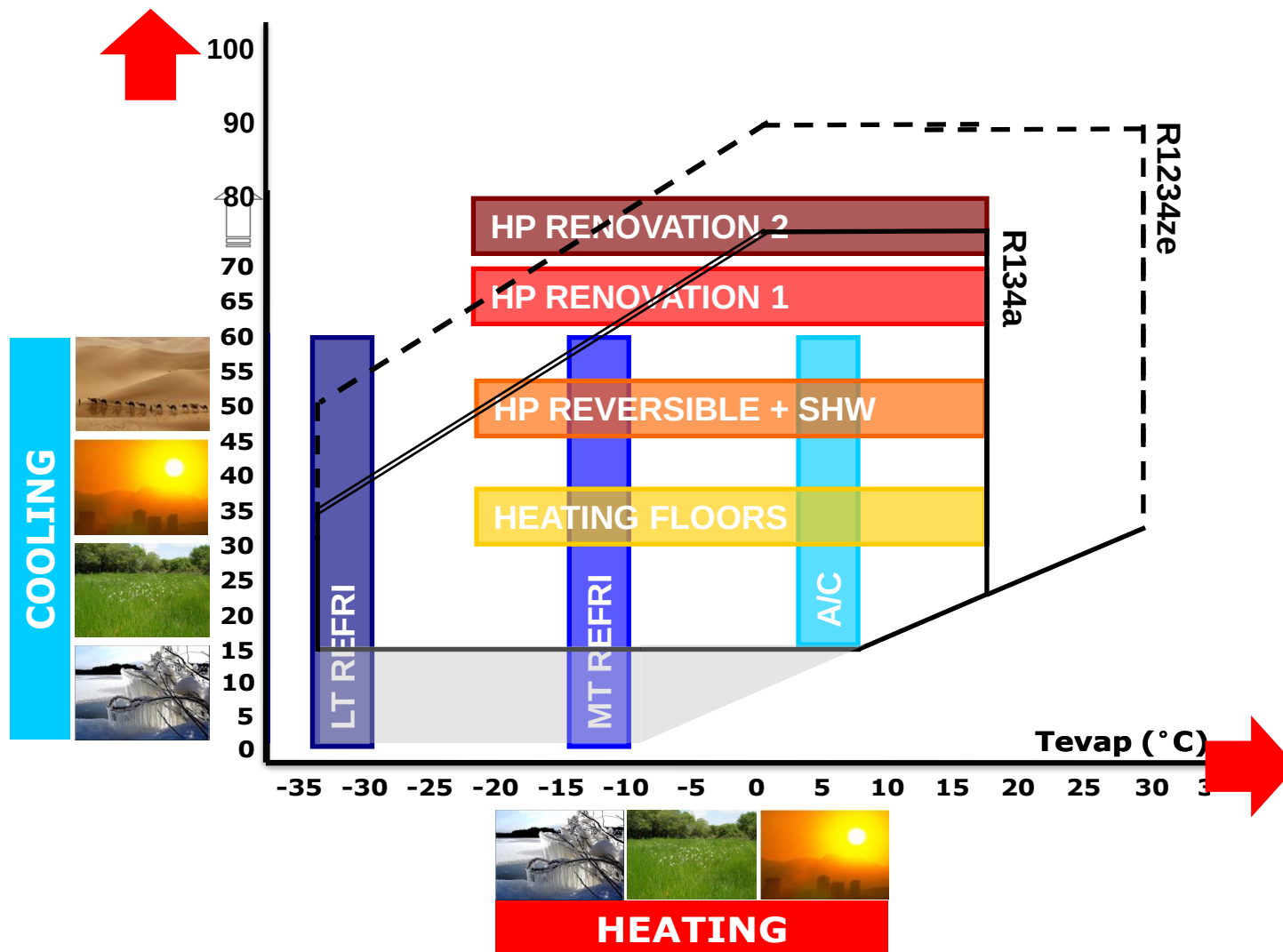
Atlas Copco validated Solstice yf use in air dryers



SolsticeTM ze

Solstice™ ze Operating envelope

Honeywell



Snapshot

$GWP_{R134a} = 1430 / A1$

$GWP_{R1234ze} = 6 / A2L$ (not flammable under 30°C)

MAP extension possible (iso Pressures and Tdischarge)

Higher Tcond achievable with R1234ze: heating market / district heating (up to 100°C possible in cascade)

Up to +5% COP reported in chiller tests

Cooling capacity -25% @ ARI conditions

Opportunity to Extend R134a Operating Range

Solstice ze first chiller

Honeywell



The first Commercial ze Chiller

Solstice™ ze Chillers - Geoclima

Honeywell



Solstice™ ze Screw Chiller



**Solstice™ ze Centrifugal Chiller
(Turbocor Compressor)**

Solstice™ ze Replacing R134a in Chillers applications

Honeywell



Danfoss
TURBOCOR

To Be Released Mid 2013

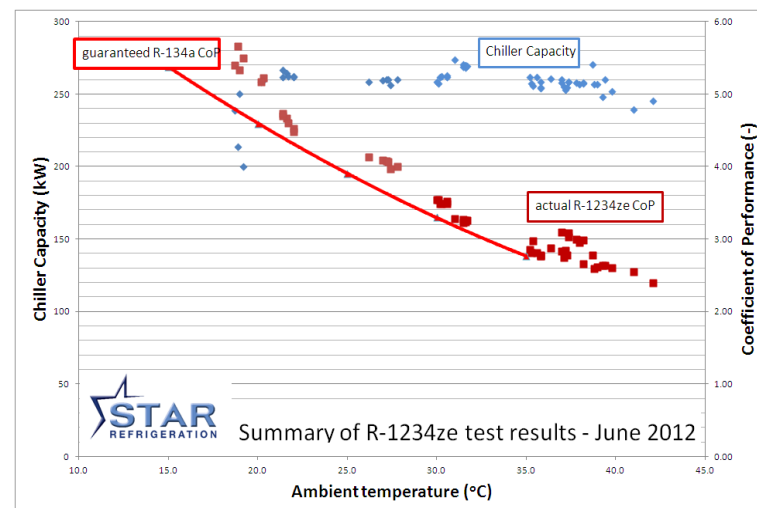
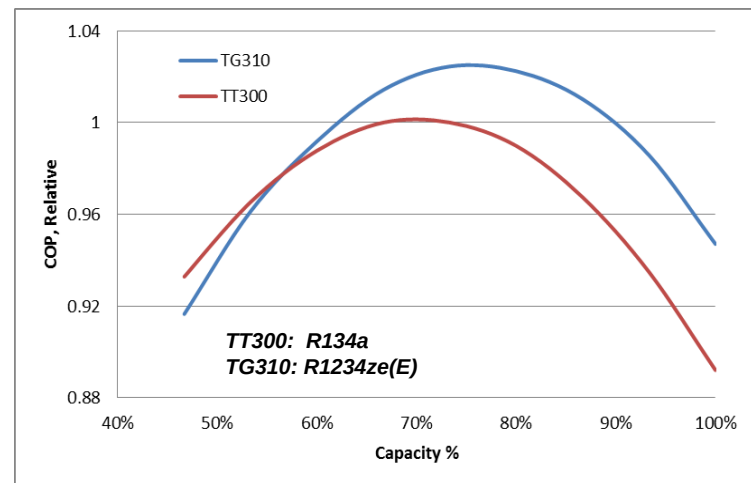
Various Compressor technologies HFO ready

KLIMA-THERM
geoclima
PROFESSIONAL AIR CONDITIONING

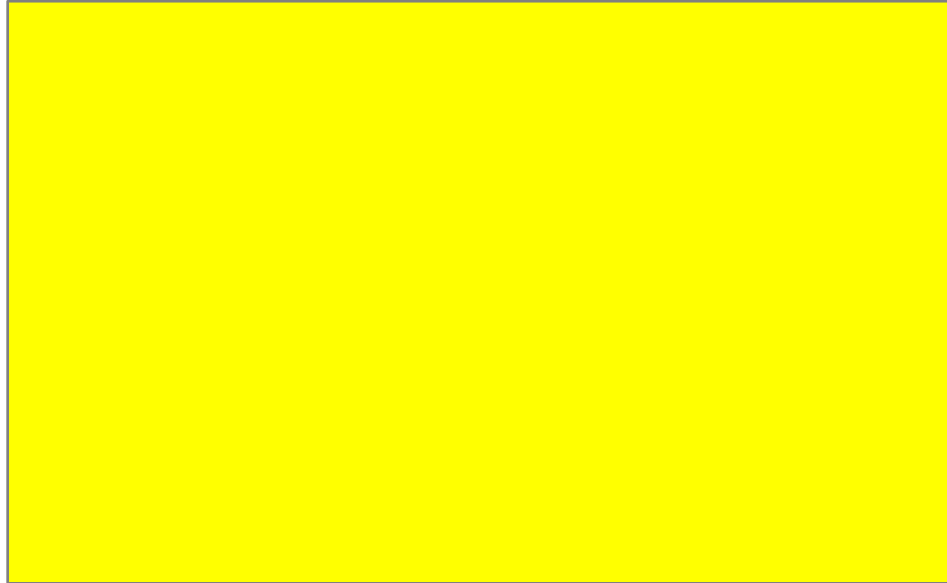
Now using
HFO
(Honeywell Solstice)
Turbomiser™

Solstice™ ze chiller installed in Honeywell's Buffalo labs

STAR
REFRIGERATION



Solstice™ ze Shows 7 to 12% Higher COP than R-134a



- ❖ Solstice TM ze an ideal fluid for District heating and cooling applications
- ❖ Successful implementation of 13MW heating installation in Norway.
- ❖ Higher COP and temperatures than R134a



Solstice™ ze based Dispensing unit.

- ❖ Manufacturer CELLI
- ❖ Displayed at Mostra & Chilventa in 2012

- ✓ Equivalent CoP to 134a
- ✓ >99.% emissions reduction
- ✓ Lower discharge pressures accross all measured ambient temperatures
 - Extended product life



Sustainability in Food & Beverage Applications in all climatic conditions; ideally suited to global distribution.

Blends

What is Genetron™ Performax LT?

Honeywell

Genetron® Performax™ LT is a ternary blend of HFC-32/HFC-125/HFC-134a. This product was developed to be used in low and medium-temperature commercial refrigeration applications, especially for retrofitting existing HCFC-22 and R-404A systems.

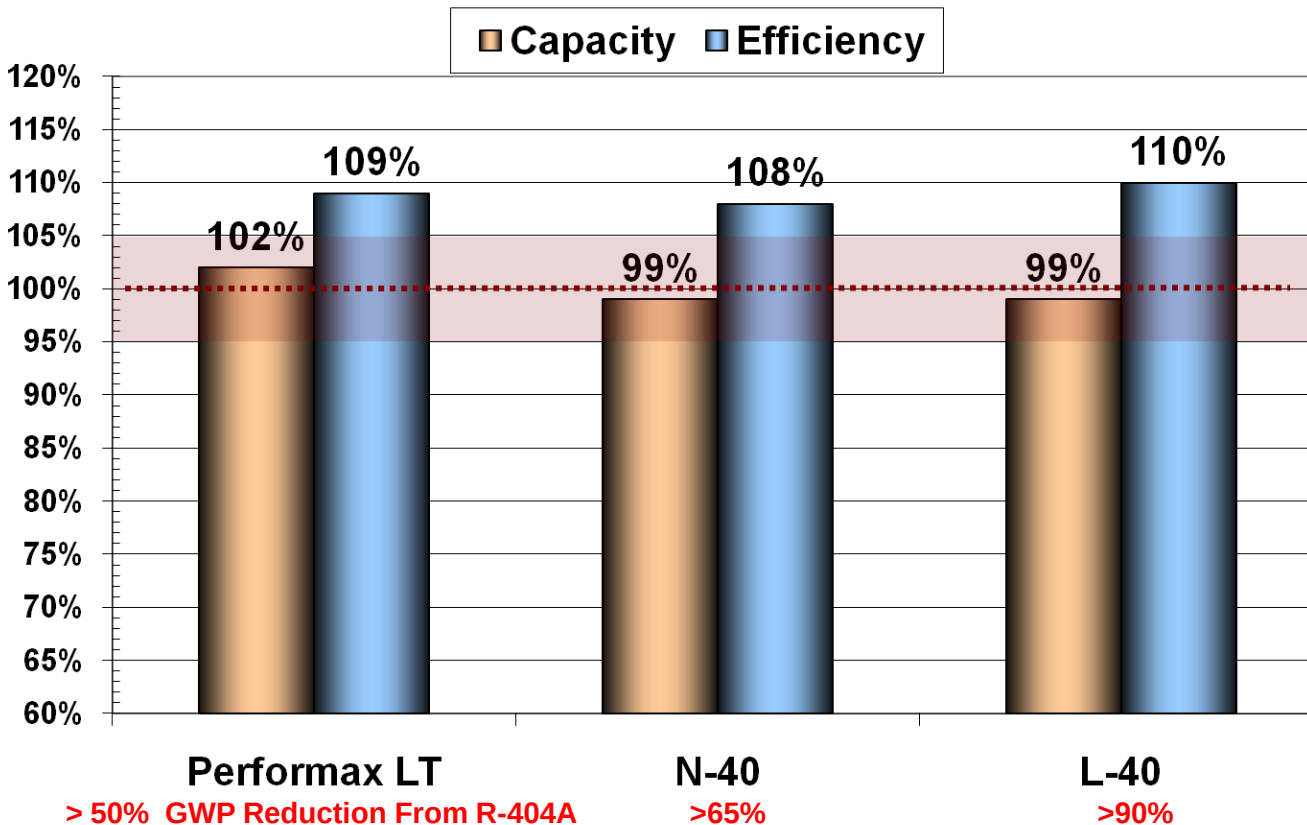
- ASHRAE R-407F
- A1 ASHRAE safety rating
- EPA SNAP approved
- Reach registered
- 100% Zero ozone depleting

**Blend of
R-32 / R-125 / R-134a
30% / 30% / 40%**



R-404A Replacement

Honeywell



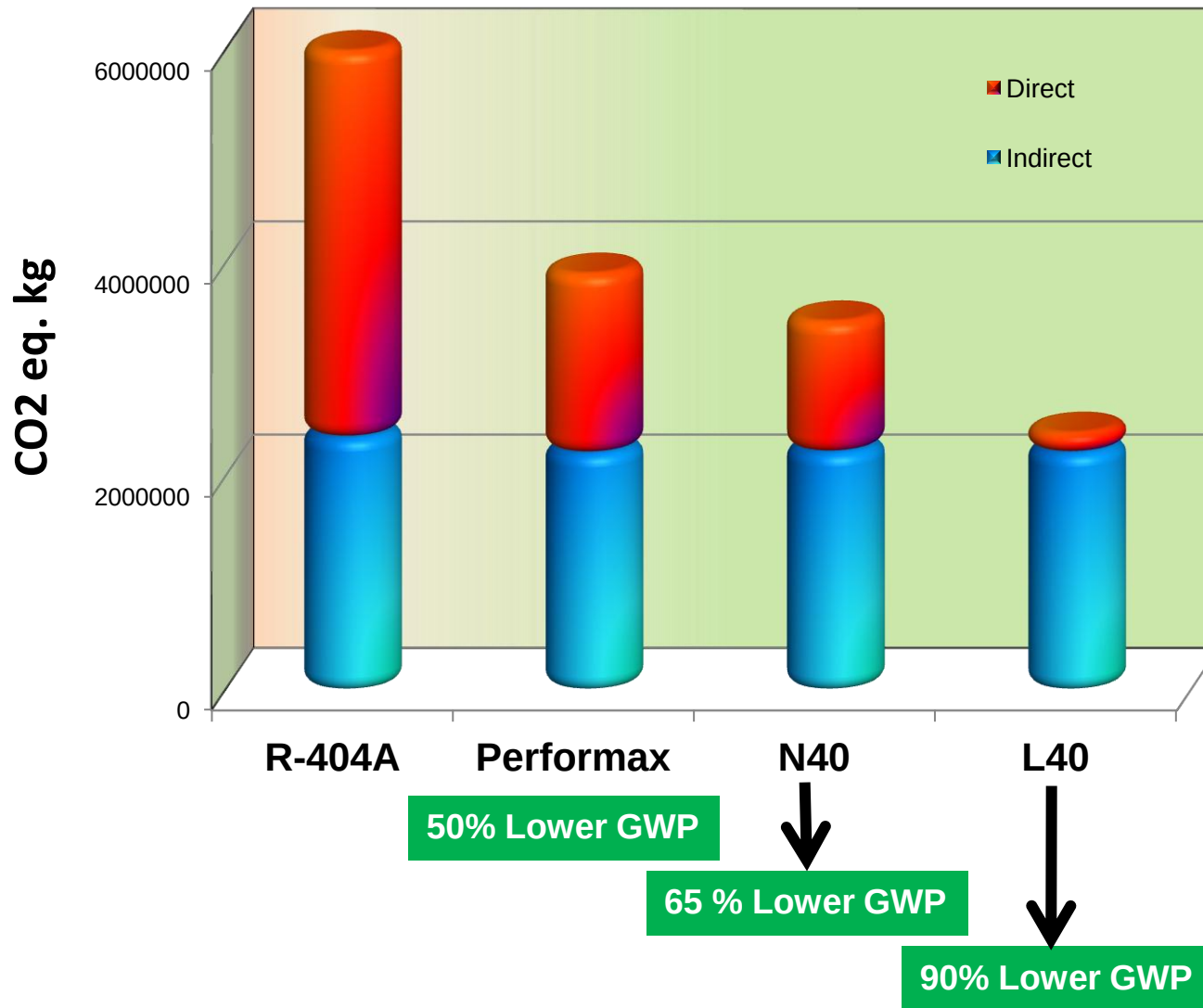
Supermarket/Deli Cases (MT)



Supermarket Freezer Cases (LT)

All options offer significantly improved Efficiency & GWP Reduction compared to R-404A

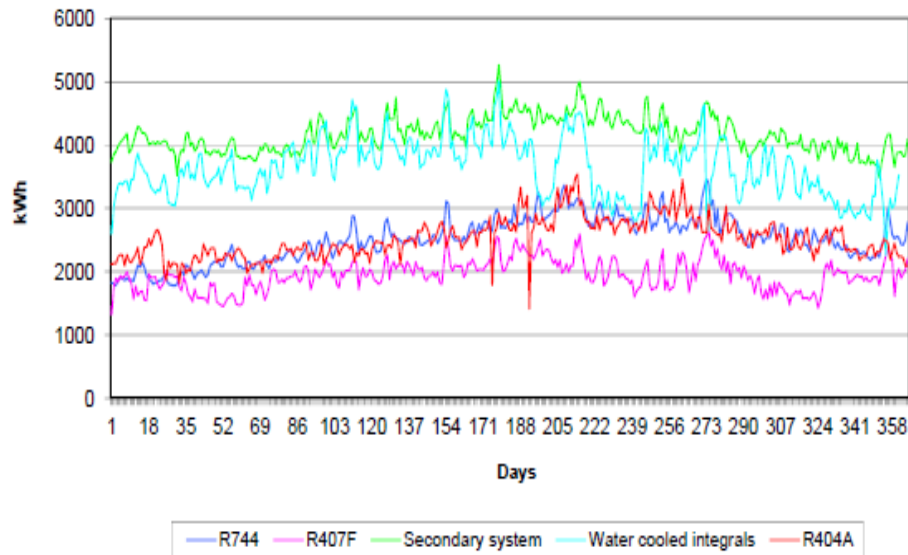
Options for the Environment



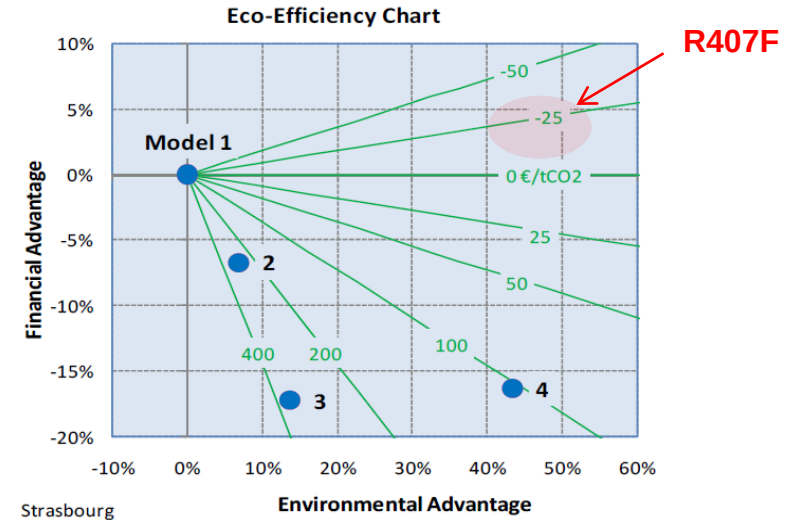
Reduced Carbon Footprint

Refrigeration systems comparison

ASDA 2011 Energy Consumption Monitoring*



- ❖ Real Life monitoring of ASDA model store, with loads within 5%.
- ❖ R407F shows lowest energy consumption and lower *environment impact*



1 = R404A system
4 = CO2 System

- ❖ R407F can reduce supermarket Carbon footprint with a positive financial advantage.

* Evaluation of available refrigeration Systems in the retail Sector, B. Churchyard & J.Bailey, IOR 2012

Solstice™ N40: first freezer counter

Honeywell



- Improved energy consumption
- Lower recovery time after defrost
- Better pull-down time
- 65% reduction in direct emissions

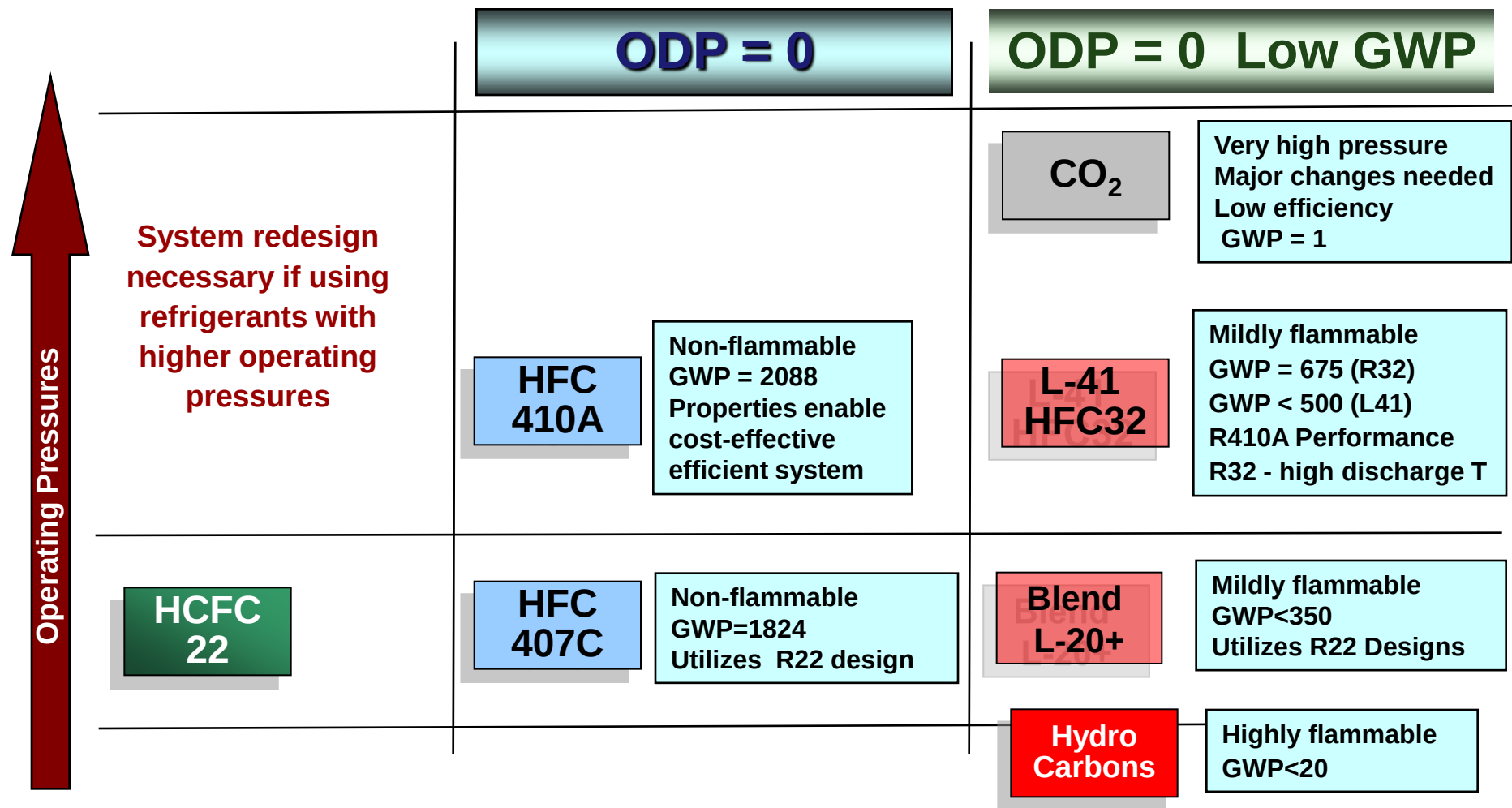


Solstice product	Type	Alternative to	GWP	Ashrae class	Performance (vs alternative)	Applications	Status
N40	HFO blend	R404A	~1300	A1	Better efficiency than R404A	LT refrigeration	Available for testing
L40			<300	A2L			

	Pulldown time (min)	Recovery time after defrost (min)	Max Tdis (°C)	kWh usage over 24 hours
R404A	78	29	85	11.44
Solstice L40	92	36	84	11.32
Solstice N40	65	24	75	10.70

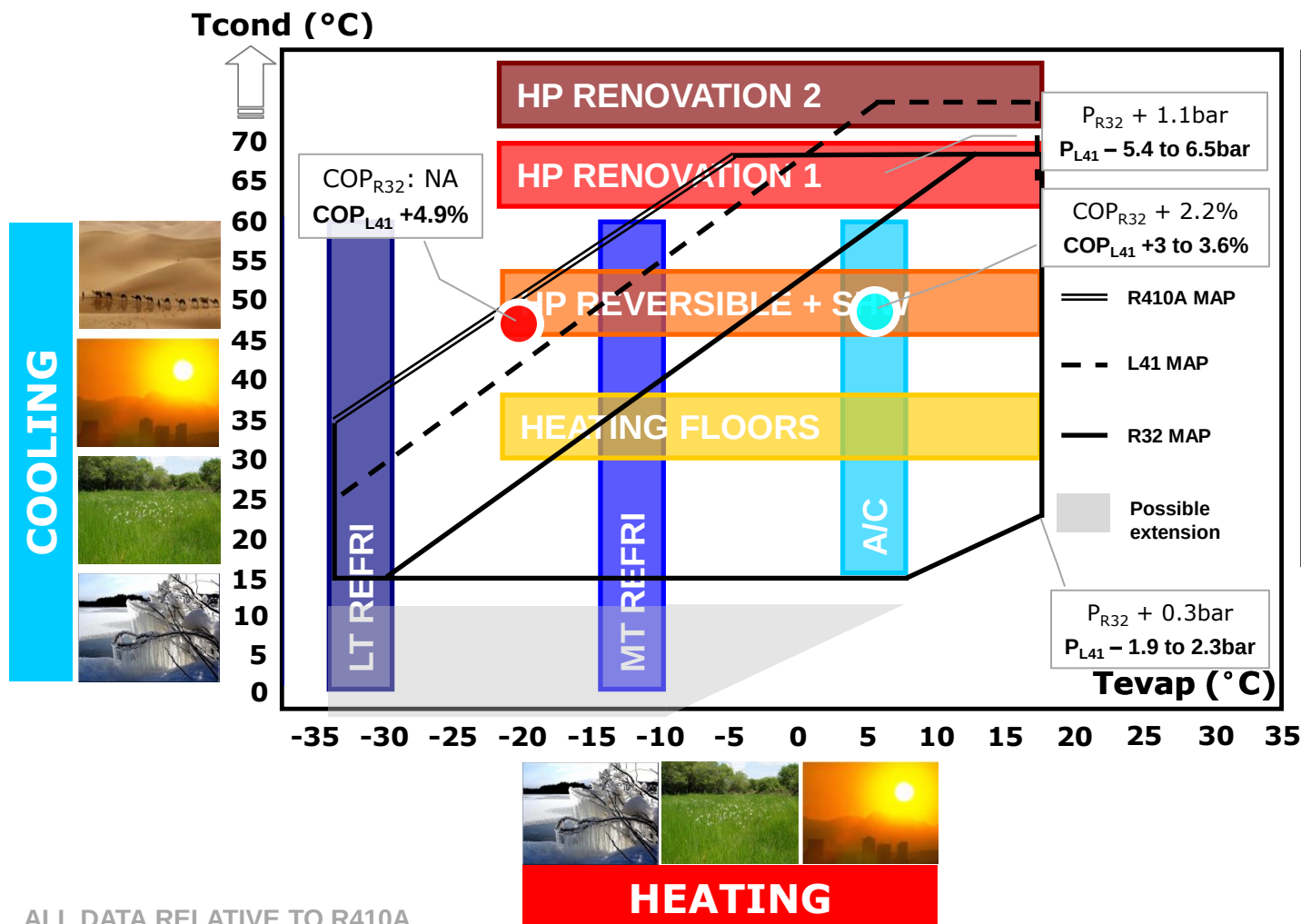
Better performance than 404A while reducing carbon footprint

Low GWP Refrigerants in AC Systems



Solstice™ L41 - Operating envelope

Honeywell



Snapshot

GWP_{R32} = 675

GWP_{L41} = 459 to 669

L41 basic MAP OK for extended applications

Both R32 & L41 will boost system COP @ rating conditions whilst L41 being the most efficient

2.2 to 7.6 bar difference in favour of L41

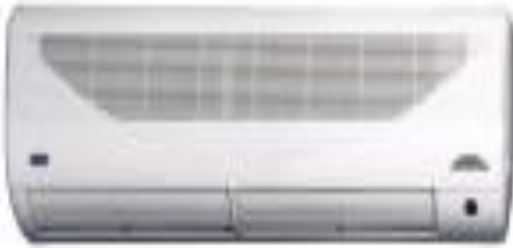
Higher Tcond achievable with L41 (heating market)

L41 10% less capacity

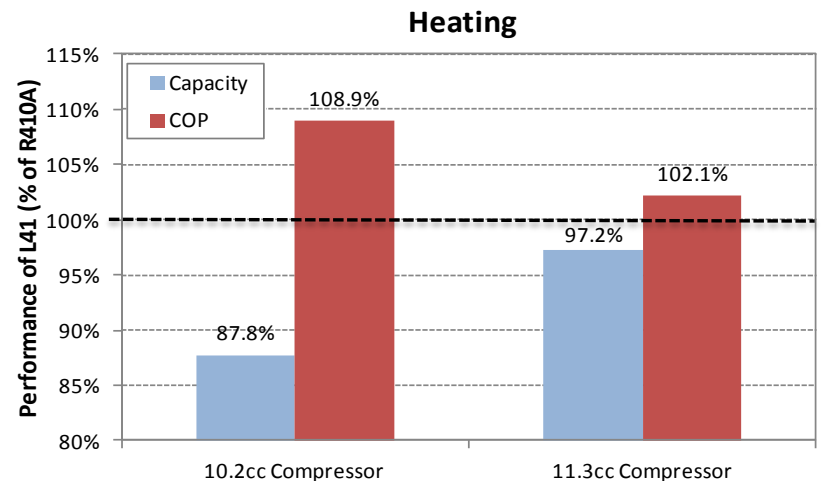
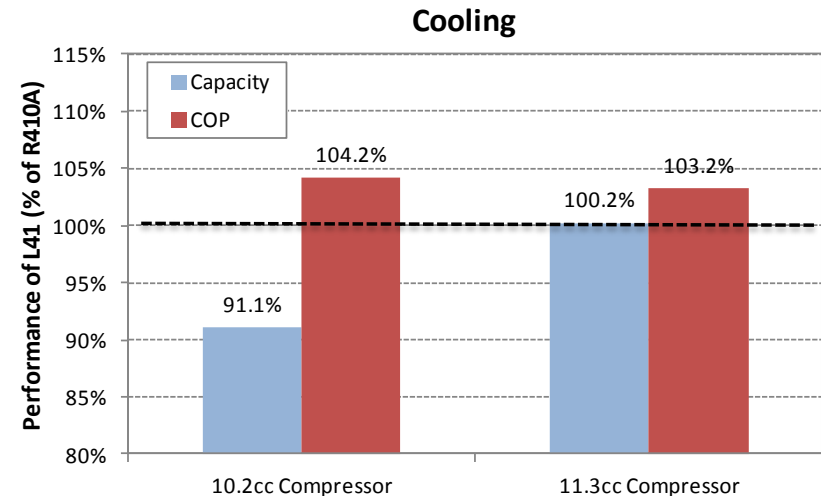
Extended Envelope to Higher Ambient Operations

Solstice™ L-41: Performance-Mini-Split System

Honeywell



- Higher efficiency achieved for both heating and cooling modes relative to R410A
- Lower capacity with nominal compressor; slightly higher displacement compressor required
- Capacity and Efficiency results match R410A performance with higher displacement compressor



Performance Results

LGWP solutions for R410A based systems developed

HFO Success Story

Honeywell

Haier

Haier Network Smart Appliance Project

- World's first Solstice L41 A/C
- A cooperative effort between:
 - Honeywell - Shanghai R&D Center
 - Haier - National Laboratory
- Presented in
 - HVAC China Jul'12
 - Chillventa Europe Oct'12
- More than 75% reduction in GWP versus R410A
- 30% reduction in GWP versus R32
- Lower discharge pressure than R32
- Lower Discharge temperature than R32
- Lower power consumption than R410A and R32 at high ambient temperature regions



海尔

Geothermal Power Plant – Sauerlach, Germany

Honeywell

- Plant type: Geothermal ORC turbogenerator unit
- Total electric power: 5+ MWel plus thermal decoupling for district heating
- Working Fluid: 245fa
- ORC Unit to be supplied by:

Turboden S.r.l.



- End Customer: SWM - StadtWerke München (public utilities company)
- Location: Bavaria, Germany
- Commissioned end 2011
- Heat source: geothermal fluid at 140°C
- Cooling device: air condensers

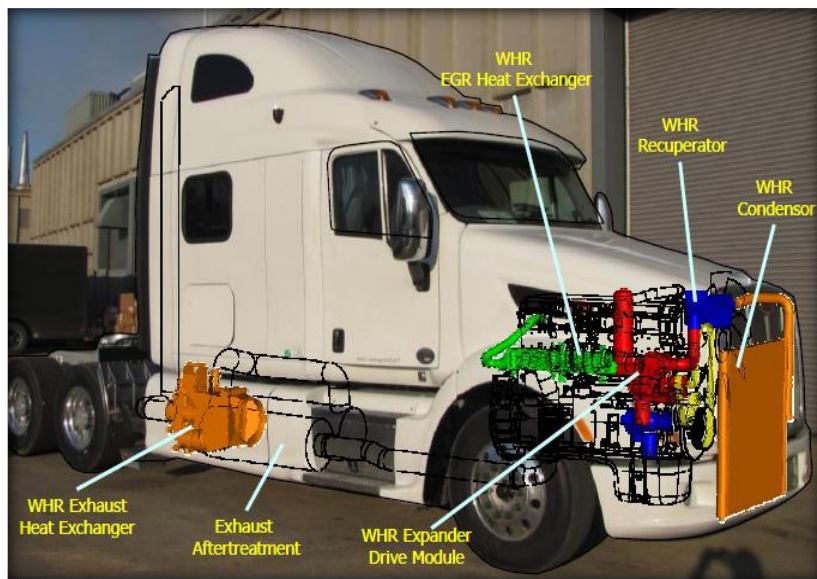


Power Cycles

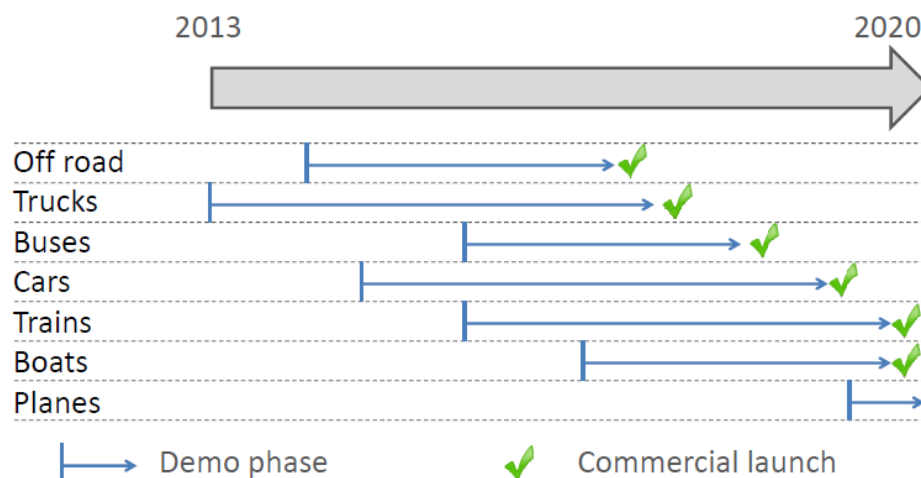
Honeywell

Recover “Waste” Heat – Turn it Into Power

- ✓ Many geothermal applications are based on 245fa.
- ✓ Mobile ORC a Potential Opportunity:
 - ❖ Drivers- Financial & regulatory.
 - ❖ Ethanol vs 245fa
 - ❖ Solstice™ zd, an alternative with higher efficiency and lower GWP.



How & when Rankine WHR vehicle applications will be marketed:



VOC indicated high interest in vehicle WHR.

Mobile ORC – An Environmental and Business Opportunity

High Temperature Heat Pumps

- ❖ Thermal energy from low temperature sources can be recovered and boosted to a more valuable temperature
 - Process usage, pre-heating, site usage
 - Offset existing thermal energy / fuel consumption
- ❖ Genetron 245fa critical temperature enables 120°C output / sink temperature
- ❖ Higher source temperatures greatly improve Efficiency (COP)
- ❖ Higher Efficiencies and temperatures expected with Solstice™ zd (GWP 5).



High Temperature Heat Pump developed for Dairy Industry.

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- ♦ **Commercialised**
 - Performax™ LT – The Most Energy Efficient Replacement for R22 in Commercial Refrigeration
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 - Solstice™ ze for Chillers and District Cooling
 - ♦ Working examples Waitrose UK / Scandinavia
 - Solstice™ yf for Mobile A/C
 - ♦ New cars in Europe / US switched
- ♦ **Development**
 - Solstice™ L41 for A/C
 - Solstice™ N and L Blends To Replace all R22/R404A

The Technology Leader in Energy Efficient HFO's

Honeywell

www.honeywell.com

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