New Case studies on Low GWP alternative refrigerants for HFCs.

ABHIJEET KUDVA

5th March 2014

Honeywell

$39-39.5B
in sales*

54%
sales outside U.S.

- 1,300 sites, 70 countries
- 132,000 employees
- Morristown, NJ headquarters
- Fortune 100

Aerospace

Performance Materials and Technologies

Automation and Control Solutions

Transportation Systems

*2013 guidance

Honeywell's refrigerants key attributes

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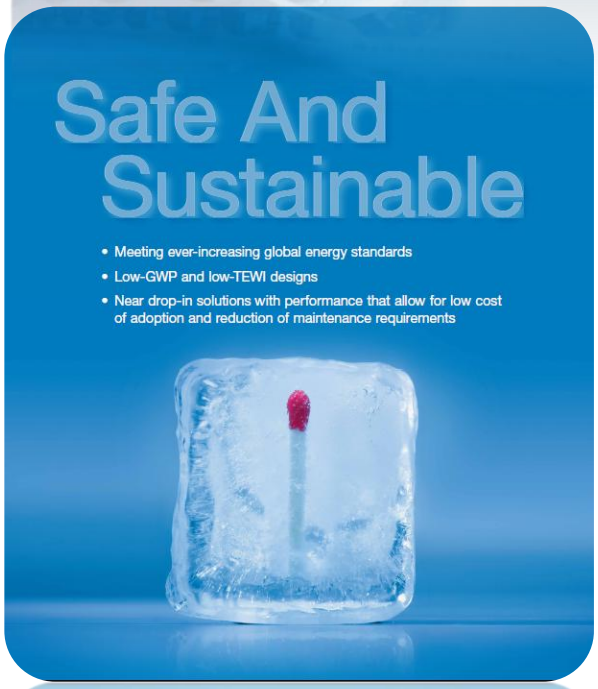

Solstice: A Growing Family of Molecules and Blends

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Auto Air-conditioning

Aerosols / Solvents

Blowing Agents

Stationary A/C and Refrigeration

Pipeline of 4th Generation Products being commercialized

Honeywell's Solstice™ low GWP refrigerants

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Solstice™ HFO's – low and medium pressure applications			
Current Product	**Non Flammable** (ASHRAE A1)	**Mildly Flammable** (ASHRAE A2L)	**Examples of Potential Applications**
HFC-134a GWP=1430		**Solstice yf** GWP <1	Auto A/C, Vending, Refrigerators
		Solstice ze GWP <1	Chillers, Heat Pumps, CO_2 Cascades, Refrigerators
R-123 GWP= 77	**Solstice zd** GWP <1		Centrifugal Chillers

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)	**Examples of Potential Applications**
HFC-134a GWP=1430	**N-13** – GWP ~600		Chillers, Med-temp Refrigeration, CO_2 Cascades
HCFC-22 GWP=1810	**N-20** - GWP ~1000	**L-20** - GWP <300	Stationary A/C, Refrigeration
R-404A GWP=3922	**N-40** - GWP~1380	**L-40** - GWP <300	Med- & Low-Temp Refrigeration
R-410A GWP=2088		**L-41** - GWP <600	Stationary A/C Applications

Low GWP Refrigerants in Stationary AC Systems

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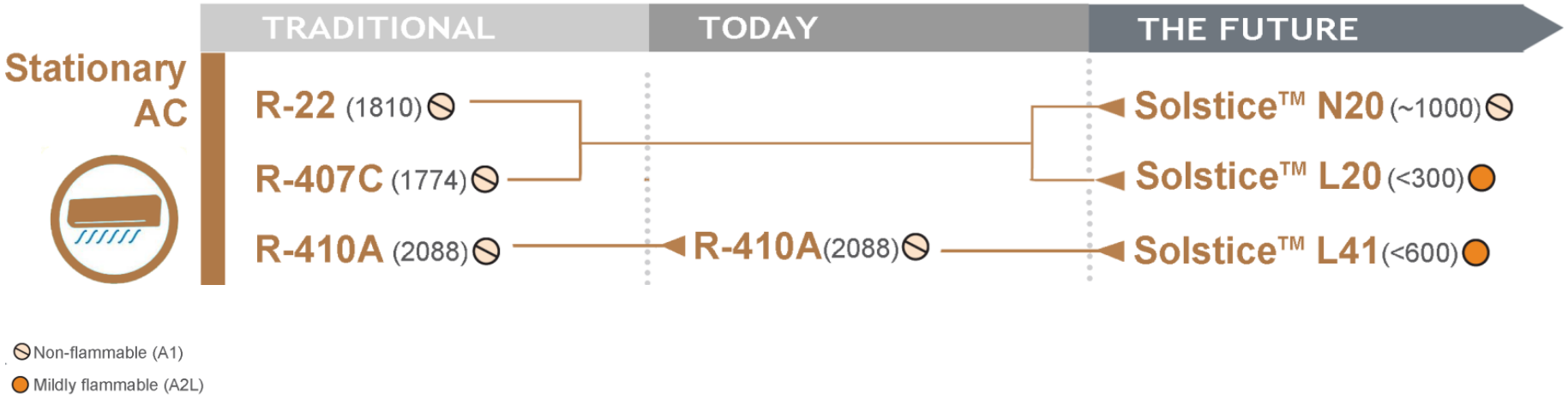

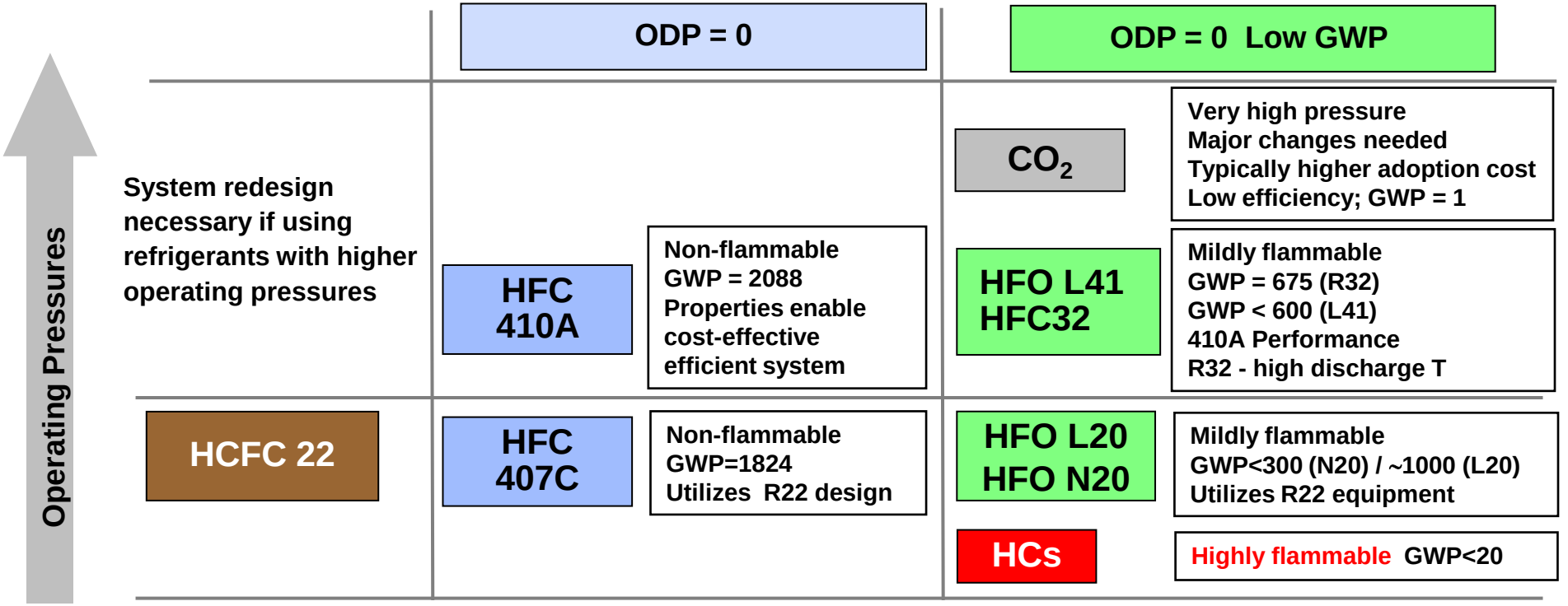

Solstice™ L41: Utilizing R410A design

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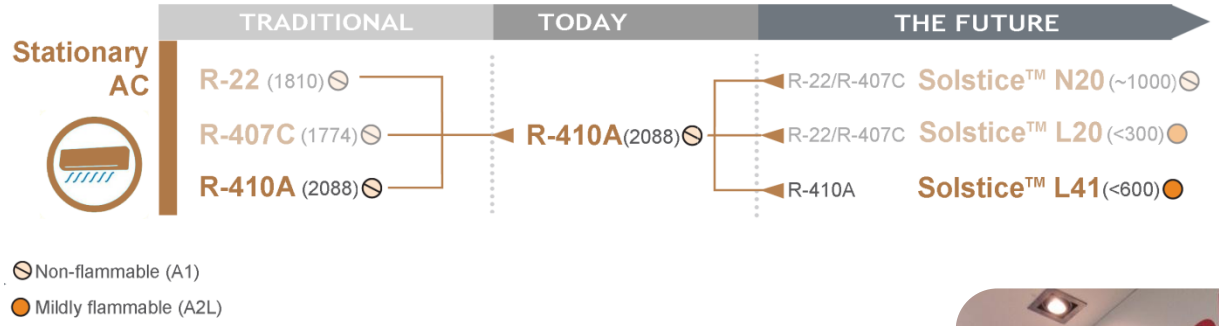

Haier Network Smart Appliance Project - World's first Solstice L41 A/C

- More than 70% reduction in GWP versus R410A
- Lower discharge pressure than R32
- Lower discharge temperature than R32
- Lower power consumption than R410A and R32 at **high ambient temperature**

Haier 海尔

Solstice™ L41 outperforms other alternatives in high ambient A/C

Solstice™ L41 vs R32 vs R410a in stationary A/C

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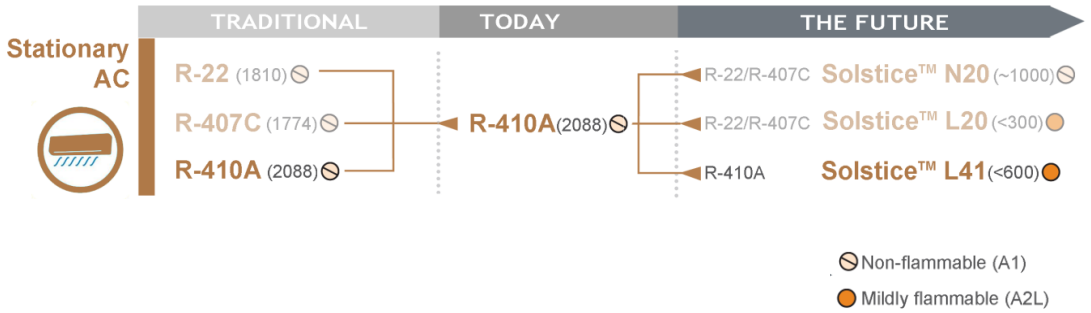
- **R-32 has been proposed as an R-410A replacement**
  - Similar performance to R-410A
  - GWP of 675, a 67% reduction



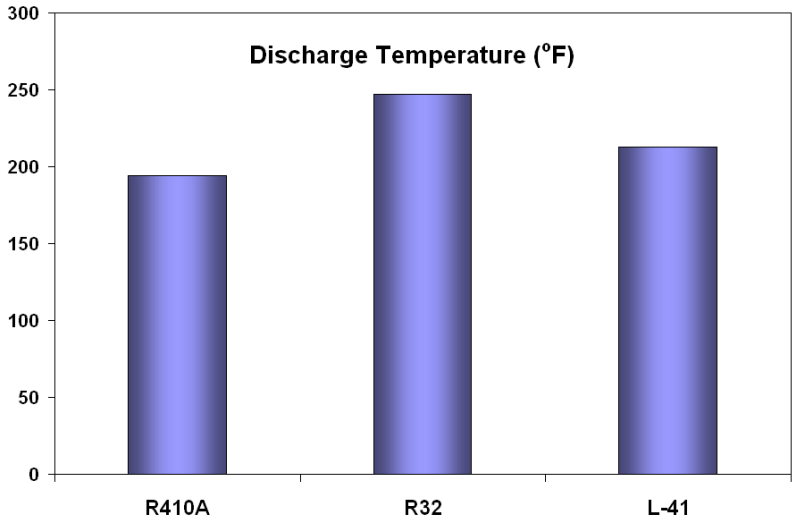
- **Solstice L41 blend outperforms R-32:**

1. GWP

- GWP of 600 for L41 vs. 675 for R-32

2. Discharge Temperature

- L41 has lower discharge temperatures than R32
- Important in very warm climates
- Less cost to mitigate



3. High Ambient Temperature Performance

- R32 power consumption increases at high temps
- Adds to peak electricity demand issues

4. Flammability

- L41 has higher minimum ignition energy and lower flame speed – lower risk
- Much less flammable than propane (R290)
- Lower cost to mitigate

HFO blends offer cost-effective performance

HFO-1234yf: lowest carbon footprint in Automobile

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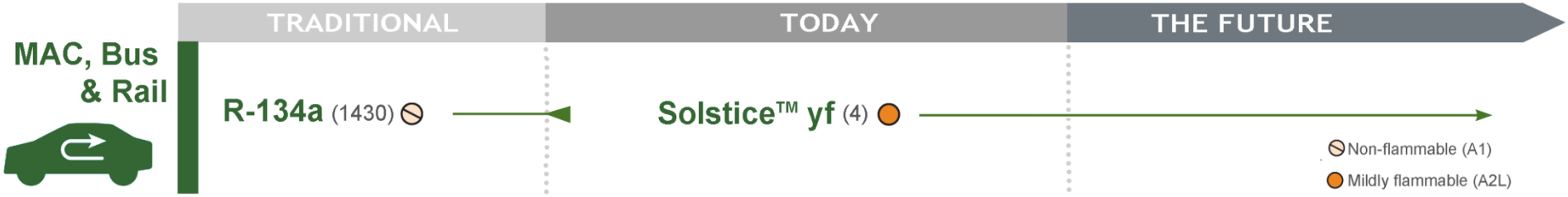
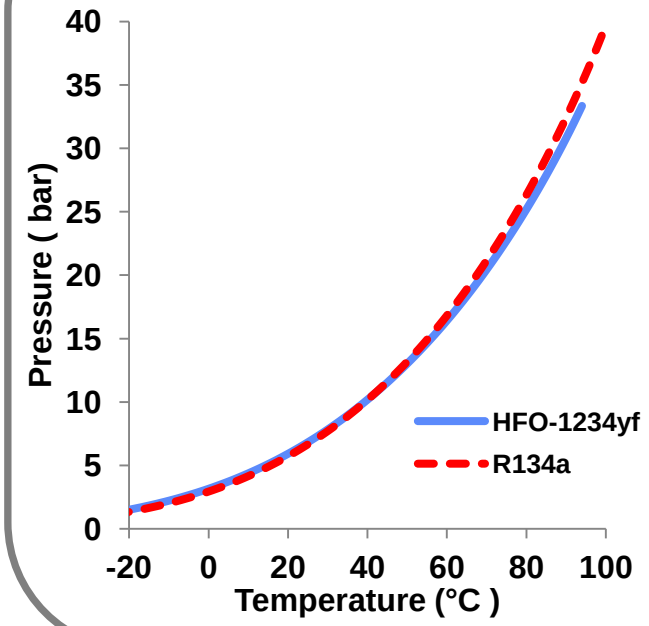
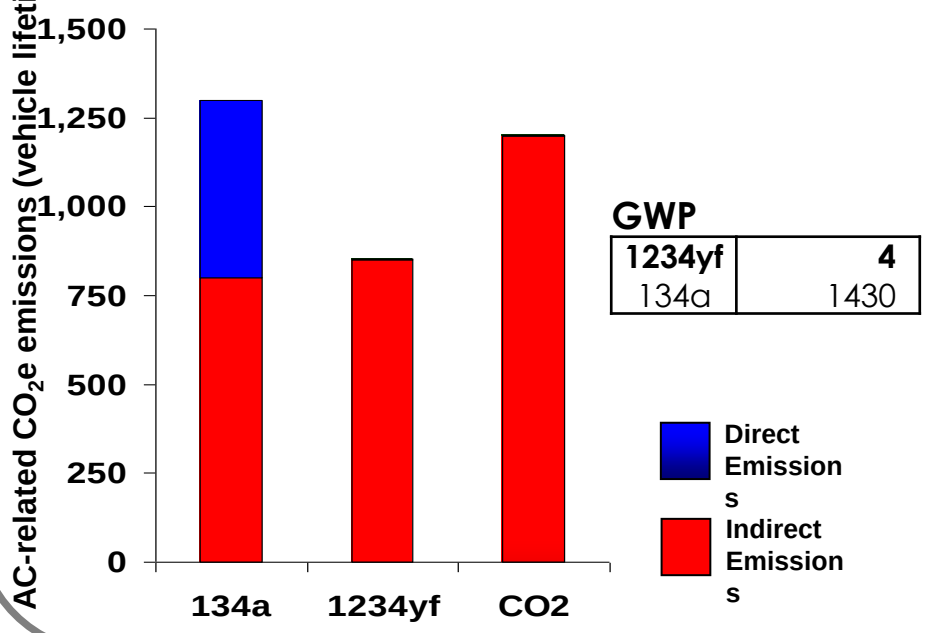


Similar performance



Lowest carbon footprint



HFO-1234yf : lowest carbon footprint of all AC technologies

Solstice ze: replacing R134a in medium pressure chillers

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- Solstice™ N13 & Solstice™ ze: similar efficiency to R134a
- Solstice N13: potential use in existing equipment
- Solstice ze good candidate for new equipment
  - Up to +5% CoP in chiller
  - Cooling capacity -25% @ ARI conditions
    - Can be overcome by design
  - Examples available in the market

Solstice ze&N13: potential use in medium pressure chillers

Solstice™ ze chillers

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Solstice™ ze Screw Chiller
(Geoclima)

Solstice™ ze Centrifugal Chiller (Geoclima, Turbocor Compressor)

Solstice™ ze in chillers in exhibition shows

Solstice zd : replacing R123 in low pressure centrifugal chillers

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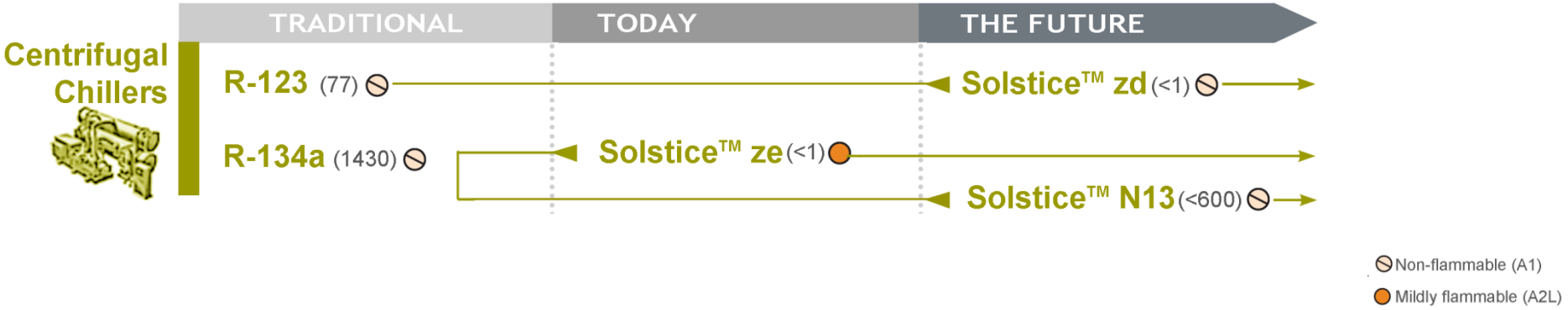

Solstice™ zd

- Replacement of R123
- Similar efficiency to R123
- It can provide higher capacity with minor system modifications
- Due to higher pressure than R123, system modifications may be required

Solstice™ zd can match efficiency of R123 and provide higher capacity

Commercial Refrigeration and 407F

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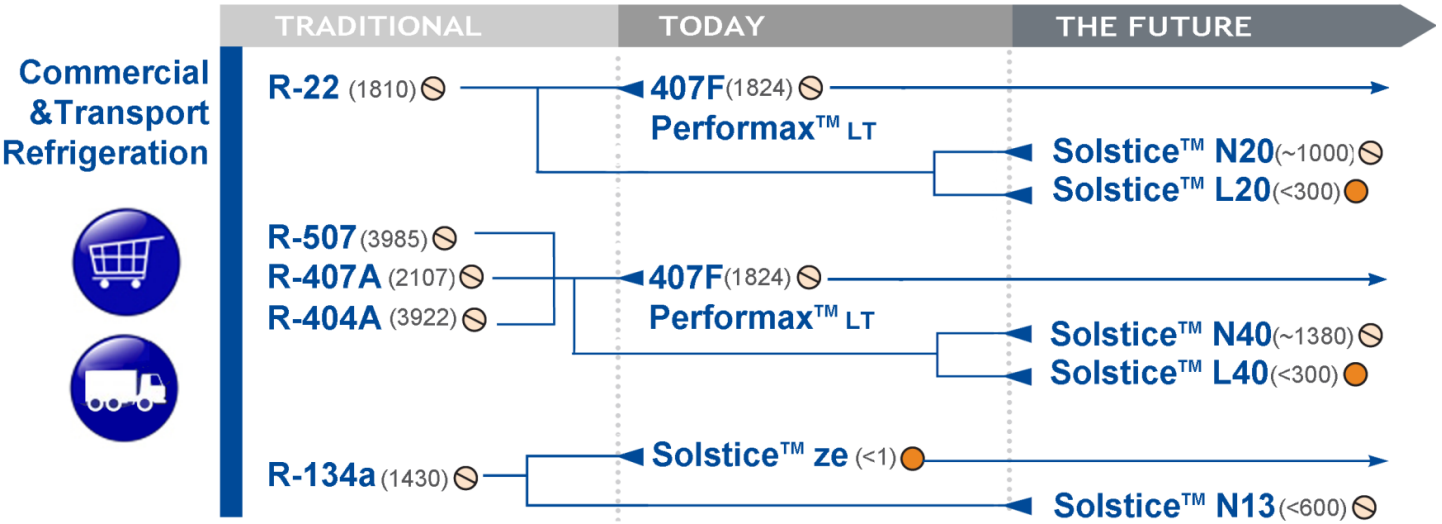

Performax™ LT: the best solution

- Mimics R22 performance
- Composed of commonly used HFC components
- Meets refrigeration specifications
- Limited modification at installation
- No change of major components
- Known system technology
- Safety and service standards as R22/R404A
- Same skills for technicians
- Same installation
- More than 600 installations and no issues

Lower GWP*

Lower energy consumption

Reduction of direct CO_2 emissions: 52%

Reduction of TEWI* up to 40%

Operations costs reduction up to 10%

*** GWP: Global Warming Potential**
TEWI: Total Equivalent Warming Impact

Best solution to improve efficiency and reduce carbon footprint & running cost

Reduced/Low GWP Options for Commercial Refr.

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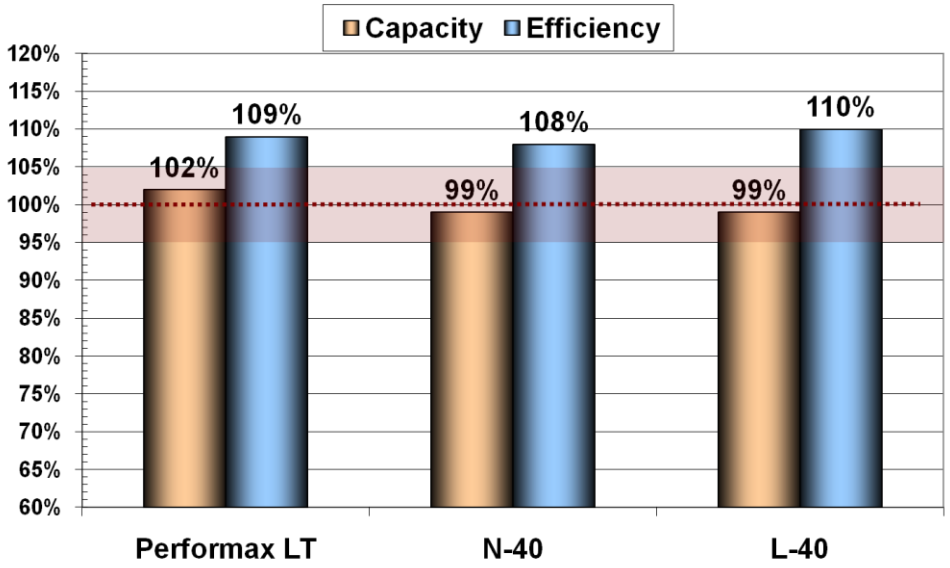

Reduced GWP Options:

- Currently available refrigerant - Performax LT (**R-407F)**
  - GWP reduction of over 50% relative to R-404A. GWP ~15% lower than R-407A.
  - Performance is superior to both R-404A and R-407A.
- We have a developmental refrigerant, N-40
  - N-40 can be used in existing R-404A equipment with little or no modifications
  - GWP reduction of over 65% as compared to R-404A with higher efficiency.

Low GWP Options:

- L-40 is the lowest GWP option that has capacity consistent with R-404A
  - GWP reduction of over 90% relative to R-404A with superior efficiency.

Conclusions

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Solstice platform key for your future

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- Stationary AC Systems
  - Solstice L41 good option as R410A replacement.
  - Outperforms other alternatives in high ambient conditions
    - High COP at high condensing temperatures
  - Solstice L20 and N20: potential alternatives to R22/R407C in residential AC
    - Solstice L20 performs well in high ambient

- High Pressure Chillers
  - Solstice L41 good option as R410A replacement
    - Minor system modifications may be required
    - Critical temperature higher than 410A&R32 → Better suited for high ambient
    - Lower GWP than 410A&R32 and lower discharge temperature than R32
  - Solstice L20 is a potential alternative to R407C

- Medium pressure centrifugal chillers – Replacing R134a
  - Solstice™ ze for new equipment: high efficiency, available on the market
  - Solstice N13 promising option for replacing R134a in existing equipment

- Low pressure centrifugal chillers
  - Solstice™ zd as replacement of R123: higher capacity, similar efficiency

Solstice platform is key for the future of your business

Commercial Status of Solstice™ Products

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Solstice™ yf

- In commercial use by auto industry now
- Sample quantities available today for stationary applications

Solstice™ ze

- Commercially available today
- Announced world scale plant for 2013

Solstice™ zd

- Commercial plant on stream 2nd quarter 2014
- Sampling for chiller, foam and solvent applications

Solstice™ Blends

- Contains Solstice ze and/or yf blended with other products
- Recently announced availability of Solstice ™ L-41
- Currently sampling to OEM's, compressor manufacturers and AREP

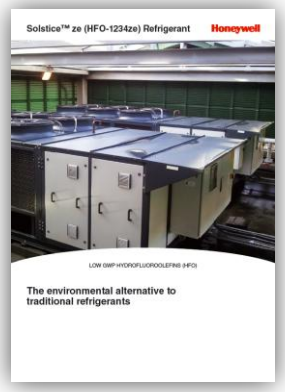
Working with Industry to Commercialize Solstice™

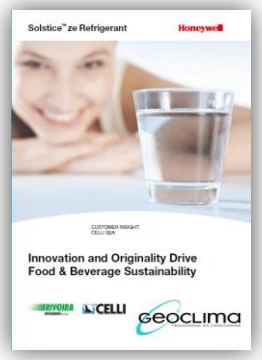
Partners all around the world

Honeywell

- Technology leadership enables our partners to
  - Achieve real progress
  - Create positive impact in their business and in their world

- Trialling Honeywell's Genetron® and Solstice™
  - Thermodynamic analysis
    - Genetron Properties Suites → most advanced simulator in the market (free)
    - Three R&D laboratories (US, India, Shanghai)
    - Experts' support
  - Samples
  - Analysis of results
  - Publications, media exposure, congresses…





We look forward to collaborating with you in trials / research programs

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www.honeywell.com