

NEXT.GEN CHILLERS —

for Low GWP Refrigerants
新一代冷水機組的研發



experience

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低碳環保製冷空調創新獎

What Is **Lower-GWP Refrigeration and Air-Conditioning Innovation Award**?

The award promotes innovative design, research and practice by recognizing people who have developed or implemented innovative technological concepts applied in developing countries to minimize global warming potential (GWP) through refrigeration and air-conditioning management.

To be eligible, work must have taken place in a developing country. Developing countries are as listed in [Article 5, Paragraph 1 of the Montreal Protocol](#) fund.

Who Are the Awarding Organizations?

Award recipients will be recognized by ASHRAE and UN Environment.

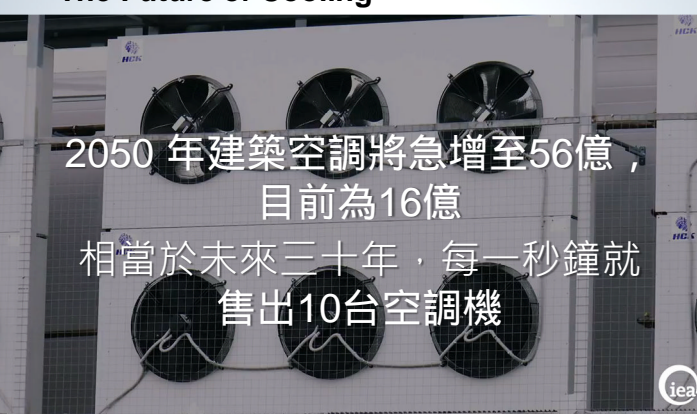
How Often Is the Award Issued/Awarded?

Annually

2019年1月至8月

Source: <https://www.ashrae.org/technical-resources/lower-gwp-refrigeration-air-conditioning-innovation-award>

空調的未來 The Future of Cooling



2050 年建築空調將急增至56億，
目前為16億
相當於未來三十年，每一秒鐘就
售出10台空調機

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影片來源：國際能源署



蒙特利爾議定書 HFC 稍減修訂

基加利修訂 — 承接迪拜HFC方案 — 全球過渡至低GWP

2016年10月15日

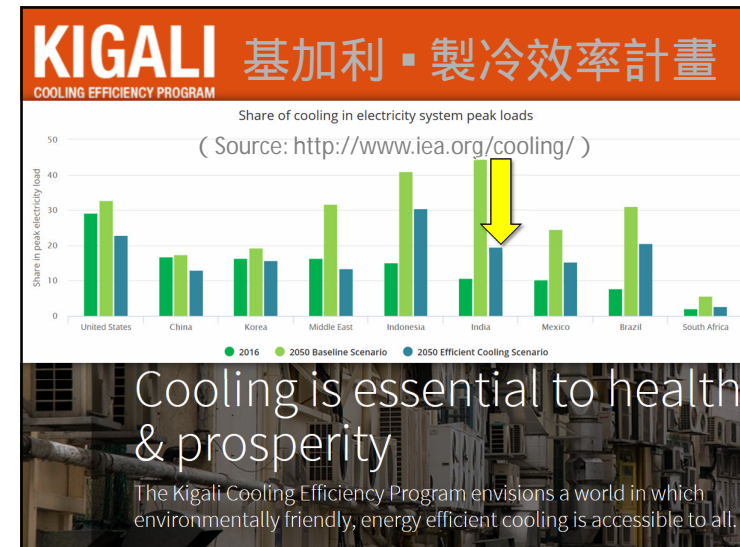
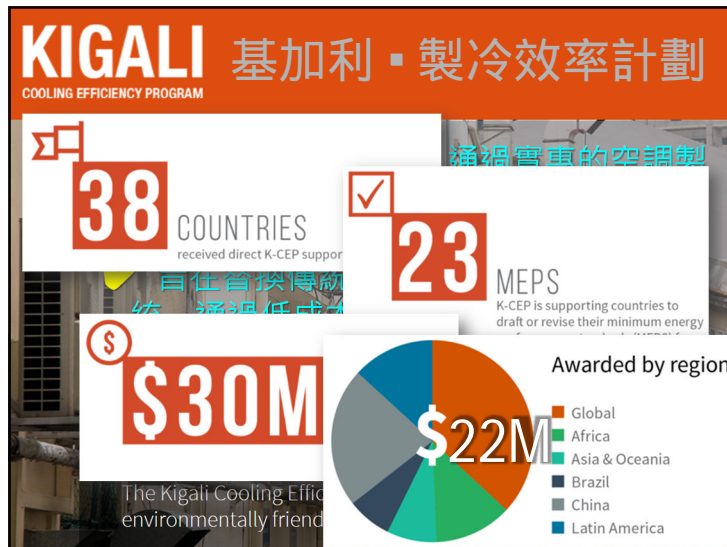
28th Meeting of the Parties to the Montreal Protocol
10 - 14 October 2016, Kigali, Rwanda



世界各國齊心對付使全球變暖的製冷劑，已達全地標性的共同協議

盧旺達基加利 — 來自170多國的代表于週六達成了一個具法律效力的協議，以應對氣候變化，在全世界範圍稍減那些導致全球變暖的化學品，包括用於空調器和冰箱。

修訂現有《蒙特利爾》在全球範圍逐步稍減HFC



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Trane first with 1233zd chiller

30 JUN 2014

FRANCE: A new non-flammable, low GWP refrigerant HFO1233zd(E) is being used for the first time in a new Trane chiller.

The Series E CenTraVac water-cooled centrifugal chiller is one of five new chillers launched by Trane and is the first chiller in the world to use the new HFO developed as an alternative to R123.

A single component refrigerant, 1233zd(E) is described as both low toxicity and non-flammable. It was originally developed for use as a blowing agent but has also been found to be a high



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MHI announces 1233zd(E) chiller

10 JUN 2015

JAPAN: Mitsubishi Heavy Industries (MHI) has adopted the new low GWP refrigerant 1233zd(E) in a smaller centrifugal chiller.

The ETI-Z series marks the world's first small-size centrifugal chillers to adopt the new refrigerant, with models being progressively introduced from September.

US manufacturer Trane became the first to use 1233zd(E) in a chiller when it announced the launch of its Series E CenTraVac last year. While the Trane chiller covers the range of 2,600kW to 14,000kW, MHI's new ETI-Z Series comes in sizes from 280kW to 2,460kW.

Also being used for foam-blowing applications, 1233zd(E) has a zero ODP and a GWP of just 1. In that respect it is seen as a long-term replacement for R134a in centrifugal chillers.



The new ETI-Z chiller joins MHI's established EHI centrifugal chiller range

MHI is a competitor of Emerson, Rand, Trane and Thermo King. MHI's published position is presented without their consent.

Carrier launches R1233zd(E) chiller

5 FEB 2017 0

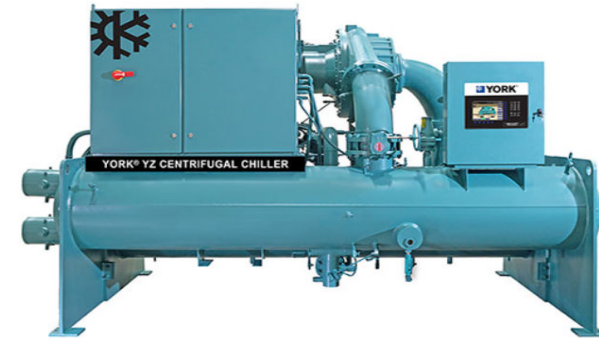


USA: Last week's AHR Expo in Las Vegas provided the platform for the official US launch of Carrier's new AquaEdge 19DV centrifugal chiller using low GWP refrigerant R1233zd(E).

Carrier is a competitor of Ingersoll Rand, Trane and Thermo King. Carrier's published position is presented without their consent.

York chiller heralds adoption of R1233zd

3 JAN 2018 0



USA: Johnson Controls' new York YZ centrifugal chiller is said to be the first such machine designed specifically for use with low GWP refrigerant R1233zd and using magnetic bearing technology.

York/JCI is a competitor of Ingersoll Rand, Trane and Thermo King. JCI published position is presented without their consent.

R513A an option in new Trane water-cooled R1234ze chiller

26 JAN 2015 0

USA: Trane launches water-cooled R1234ze chiller

The refrigerant markets as available in Trane's recent Sintesis air-conditioning option will be North America from Japan.



USA: Ingersoll Rand has added a further Trane water-cooled chiller using the low GWP HFO refrigerant R1234ze. The new XStream excellent chiller joins Ingersoll Rand's EcoWise portfolio of low environmental impact products. With capacities ranging from 290kW to 2600kW, the XStream excellent is said to be suited to critical environments such as a data centre, hospital, large office building or and trailer refrigeration products using DuPont's Opteon X.

Green back Midea adopts R32 and HFO blends

16 NOV 2014 25 APR 2017 0

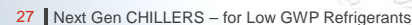
GERMANY: R32 in V...
environmental
backed by
as the
refrigerant
JAPAN: A...
safety g...
VRF sys...
Although
servicing with
on January
phase-out
still one o...
refrigerant

Lower GWP...
but most...
efficiency...
condition...
range 0...
thermodynamic properties also



USA: Chinese air conditioning manufacturer Midea is to use R452B, a lower GWP alternative to R410A, in its unitary air conditioning units designed for the North American market. Originally developed by Chemours as DR-55 and now marketed as Opteon XL55, R452B has a GWP of 676, around 65% less than that of R410A. Midea is a competitor of Ingersoll Rand, Trane and Thermo King. Midea published position is presented without their consent.

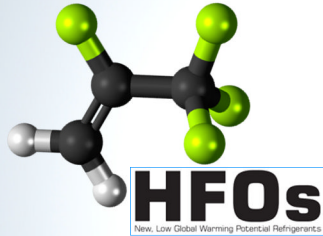
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The New "HFOs"



• Unsaturated fluorinated fluid:

- Performance characteristics similar to HFC/HCFC
- **Very short atmospheric life**
- GWP and flammability trade-off

▪ Commercially available:

- R1234yf, GWP <1
 - Automotive "drop-in" for R-134a
 - **Atmospheric life = 14 days**
 - Slightly flammable (A2L)
- R1234ze(E), GWP <1
 - Refrigeration, not a "drop-in"
 - **Atmospheric life = 14 days**
 - Slightly flammable (A2L)
- R1233zd(E), GWP ~1
 - Foam blowing
 - **Atmospheric life = 36 days**
 - Non-flammable (A1)
- R1336mzz(Z), GWP 8.9
 - Foam expansion
 - **Atmospheric life = 24 days**
 - Non-flammable (A1)
- R1224yd(Z), GWP <1
 - R245fa replacement
 - **Atmospheric life = 21 days**
 - Non-flammable (A1)

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New "HFO" Refrigerants

ASHRAE Standard 34

- 000 Series Methane Based, e.g. R-11, -12, -22, -32
- 100 Series Ethane Based, e.g. R-123, -125, -134a,
- 200 Series Propane Based, e.g. R-227ea, -245fa, -290
- 300 Series Cyclic Organic Compounds
- 400 Series Zeotrope, e.g. R-404A, -410A, **-452A, -452B**
- 500 Series Azeotrope, e.g. **R-513A, -514A, -515A**
- 600 Series Organic Compounds, e.g. R-600
- 700 Series Inorganic Compounds, e.g. R-717, -744
- 1000 Series Unsaturated Organic Compounds, e.g. **R-1234yf, -1234ze(E), -1233zd(E), -1336mzz(Z), -1130(E), -1224yd(Z)...**

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Application Considerations

Major Product Categories

- Scroll and reciprocating compressors
 - Smaller equipment, 100 tons and below
- Screw compressors
 - Medium size equipment, 100-450 tons
 - Used on medium and large commercial applications
- Centrifugal Compressors
 - Large equipment, 300+ tons
 - Used on large commercial/industrial properties



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Application Considerations

Scroll and Recip Compressors

Current Offering

- **R-22**
 - GWP 1810
 - ODP 0.055
 - Non-flammable
- **R-410A**
 - GWP 2100
 - Non-flammable

Next Generation

- **R-452B** (HFO blend)
 - GWP 676
 - R410A "drop-in"
 - 2L, BV 3.0 cm/s, MIE 200 mJ
- **R-32**
 - GWP 675
 - New design
 - 2L, BV 6.7 cm/s, MIE 29 mJ

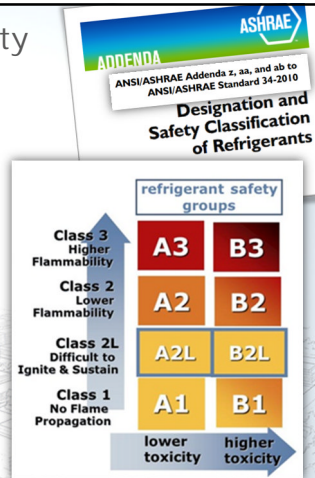
Comments:

- Cost sensitive segment
- No non-flammable alternative, safety concerns
- GWP level consensus



Refrigerant Flammability

- ASHRAE 2L Flammability Class
 - Created in 2010
 - "Difficult to Ignite & Sustain"
 - Key for many new refrigerants
- Current 2L Refrigerants:
 - R-1234yf
 - R-1234ze(E)
 - R-32
 - R-717 (Ammonia)
- 2L Definition Being Evaluated
 - Not all 2L fluids are equally safe
 - Burning Velocities <5 cm/s under consideration
 - Not yet covered by ASHRAE Std.15



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Application Considerations

Screw Compressors

Current Offering

- R-22**
 - GWP 1810
 - ODP 0.055
 - Non-flammable
- R-134a**
 - GWP 1430
 - Non-flammable

Next Generation

- R-513A** (HFO blend)
 - GWP 573, non-flammable
 - Performance similar to R134a
- R-1234ze** (medium pressure HFO)
 - GWP <1, 2L flammability
 - Efficiency same as R134a
 - Capacity loss 10~20%
- R-1234yf** (medium pressure HFO)
 - GWP <1, 2L flammability
 - Efficiency loss 4%
 - Same capacity as R134a

Comments:

- Low GWP option with flammability concerns
- Higher GWP easy transition

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Application Considerations

Centrifugal Compressors

Current Offering

- R-123**
 - GWP 77
 - ODP 0.02
 - Non-flammable
- R-134a**
 - GWP 1430
 - Non-flammable

Next Generation

- R-514A** (low pressure HFO blend)
 - GWP <2, non-flammable
 - Performance similar to R123
- R-1233zd** (low pressure HFO)
 - GWP 1, non-flammable
 - 10% more efficient than R134a



R-1234ze

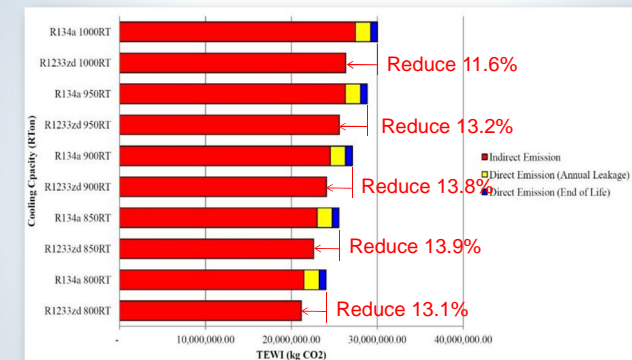
- GWP <1, 2L flammability
- Efficiency same as R134a
- Capacity loss 10~20%

Comments:

- Most efficient market segment
- Widespread options by 2020

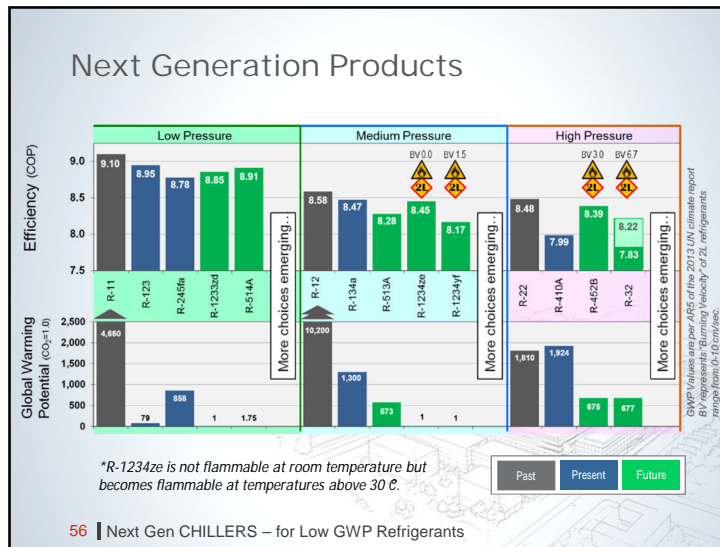
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Performance Studies



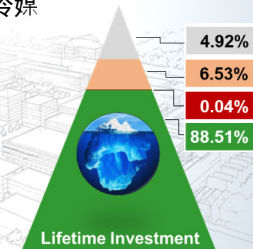
Total Equivalent Warming Impact

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Takeaway 結語

- R-123, R-134a, R-410A... 這些現有冷媒都會過渡至下一代方案，如：R-1233zd, R-514A, R-513A等等
且過渡現在已經開始了
- 首先採用非易燃性低GWP的HFO類冷媒
環境與安全都須顧及
- 為我們的下一代著想
考量全生命周期的投資、總碳排放、
擁有物業的整體成本



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