



Next Generation Refrigerant

– One of the Most Balanced Refrigerant Solution for the Environmental issue

08.Oct.2013

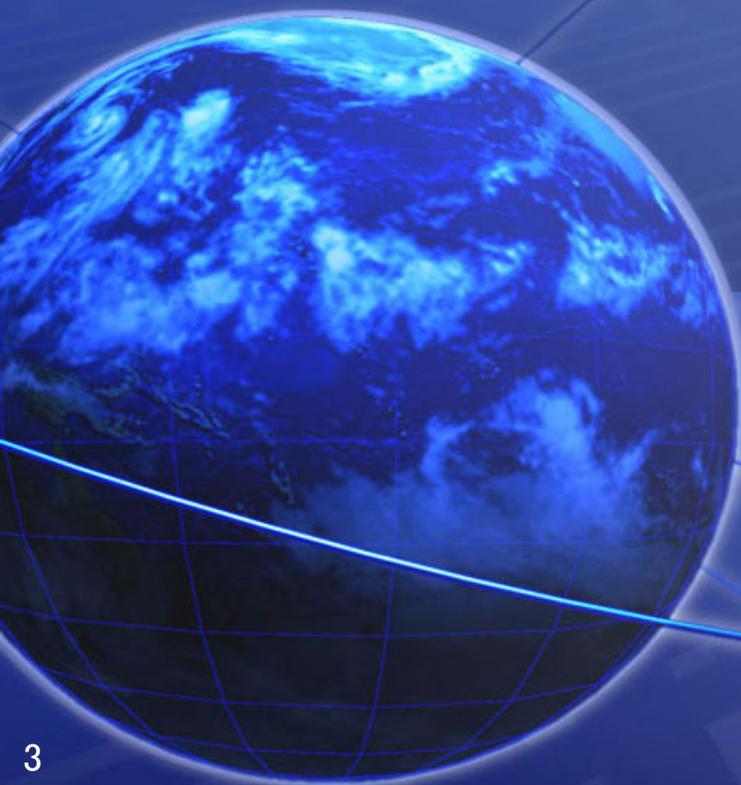
DAIKIN

M. MATSUI

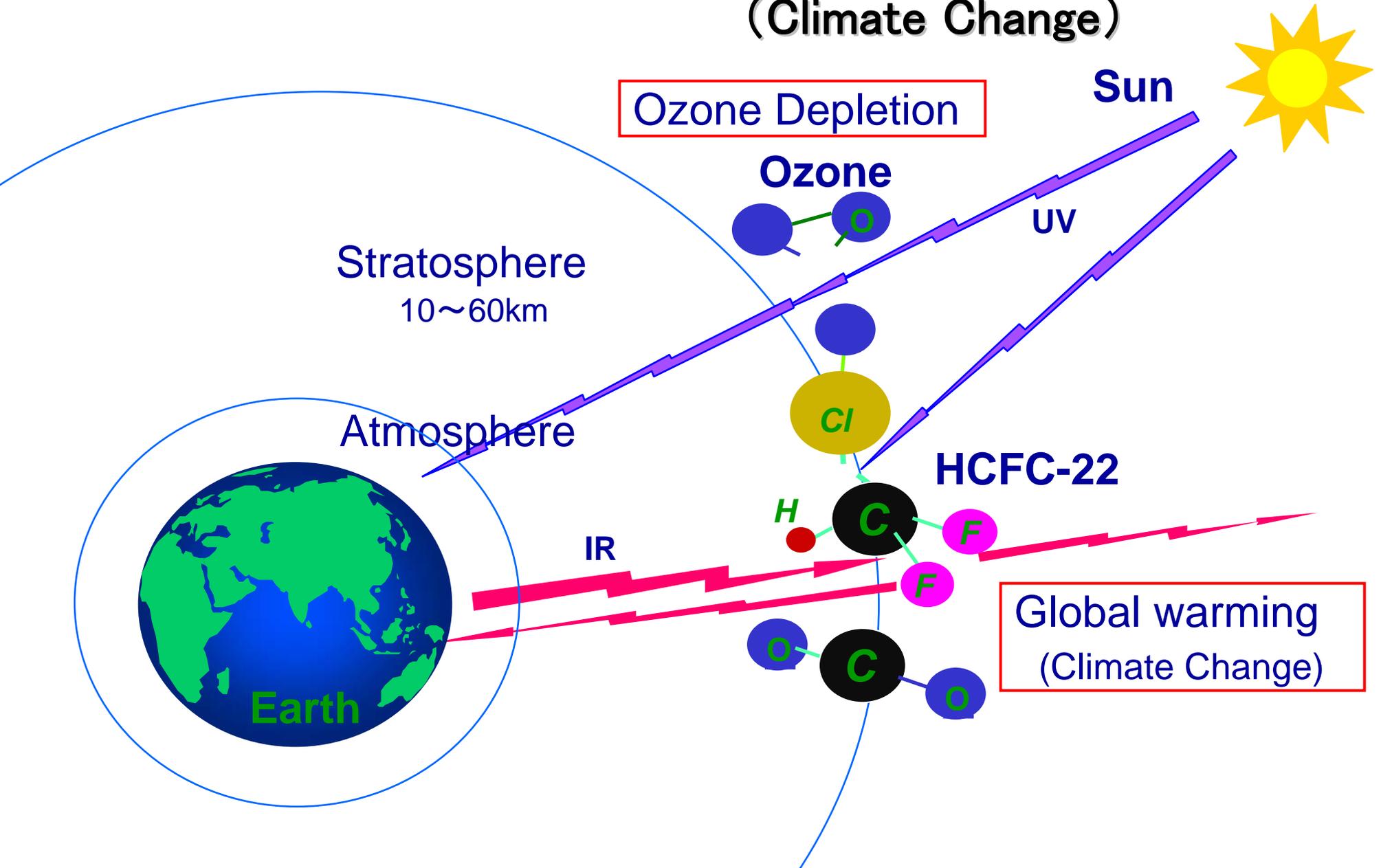
Contents

1. Overview
 - ... Worldwide movement for the Refrigerant
2. Alternative Refrigerant R32 in Air-conditioning
3. Current Situation and Issues on Replacing HCFCs in ASEAN countries.

Overview



Ozone Depletion and Global warming (Climate Change)



Worldwide efforts (by UN's leading)

- Ozone depletion ⇒ ◇ Montreal Protocol ;
 - CFC reduction started from '87
 - HCFC reduction target was set in '92 and started to reduce

Advanced countries	CFC (R12) ⇒ HCFC (R22) ⇒ HFC (R410A)	⇒	?
Developing countries	⇒ HCFC (R22)	⇒	HFC (R410A) ⇒ ?

• Low GWP HFC
 • HC , • Natural

- Global warming (Climate change) ⇒ ◇ Kyoto Protocol ;
 - adopted in '97 and have been discussed and done

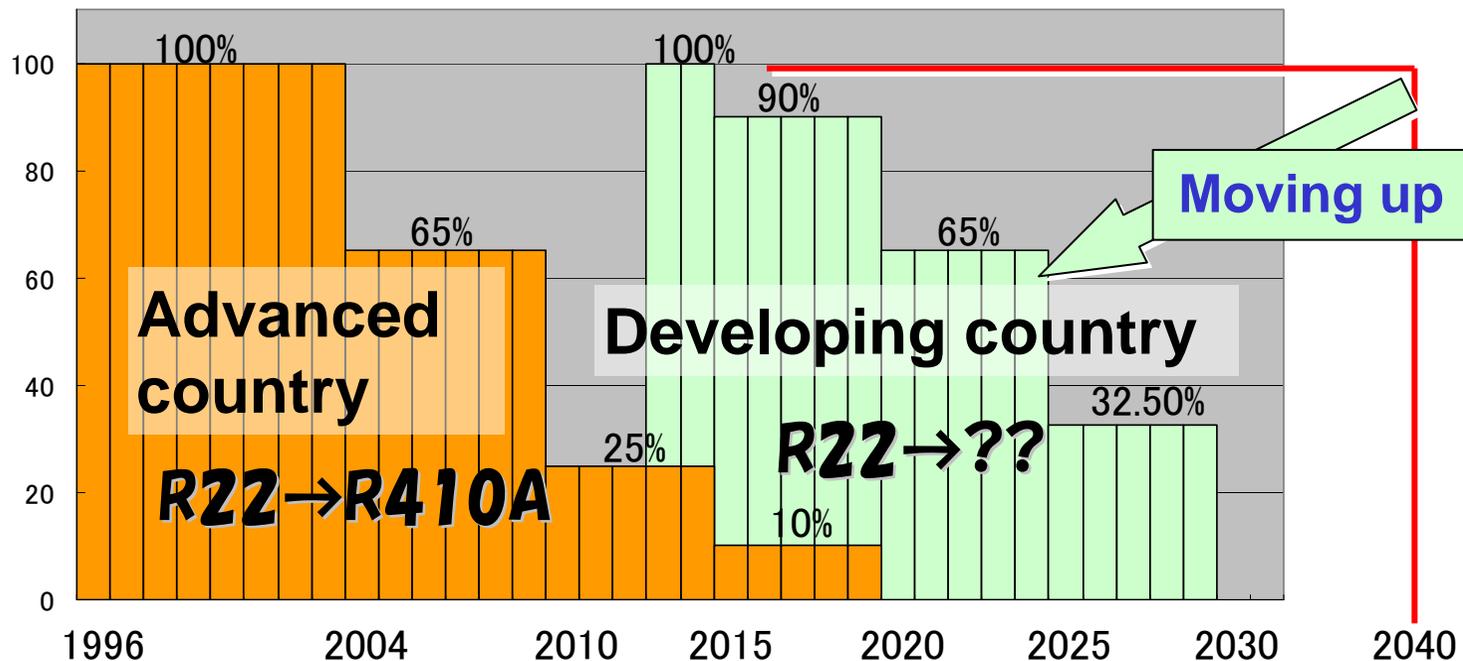
Advanced countries	CO2 reduction mainly in EU countries and Japan
Developing countries	First of all, advanced countries should owe the CO2 reduction burden.

◇ Protection of the Ozone depletion

Current status

- Worldwide taking action of HCFC phase-out.
- Such action had almost finished for advanced countries.
- Now the action is accelerating for developing countries.
= **HPMP** (HCFC Phase out Management Program) submission to UN

HCFC phase-out schedule





HCFC phase-out plan in this region

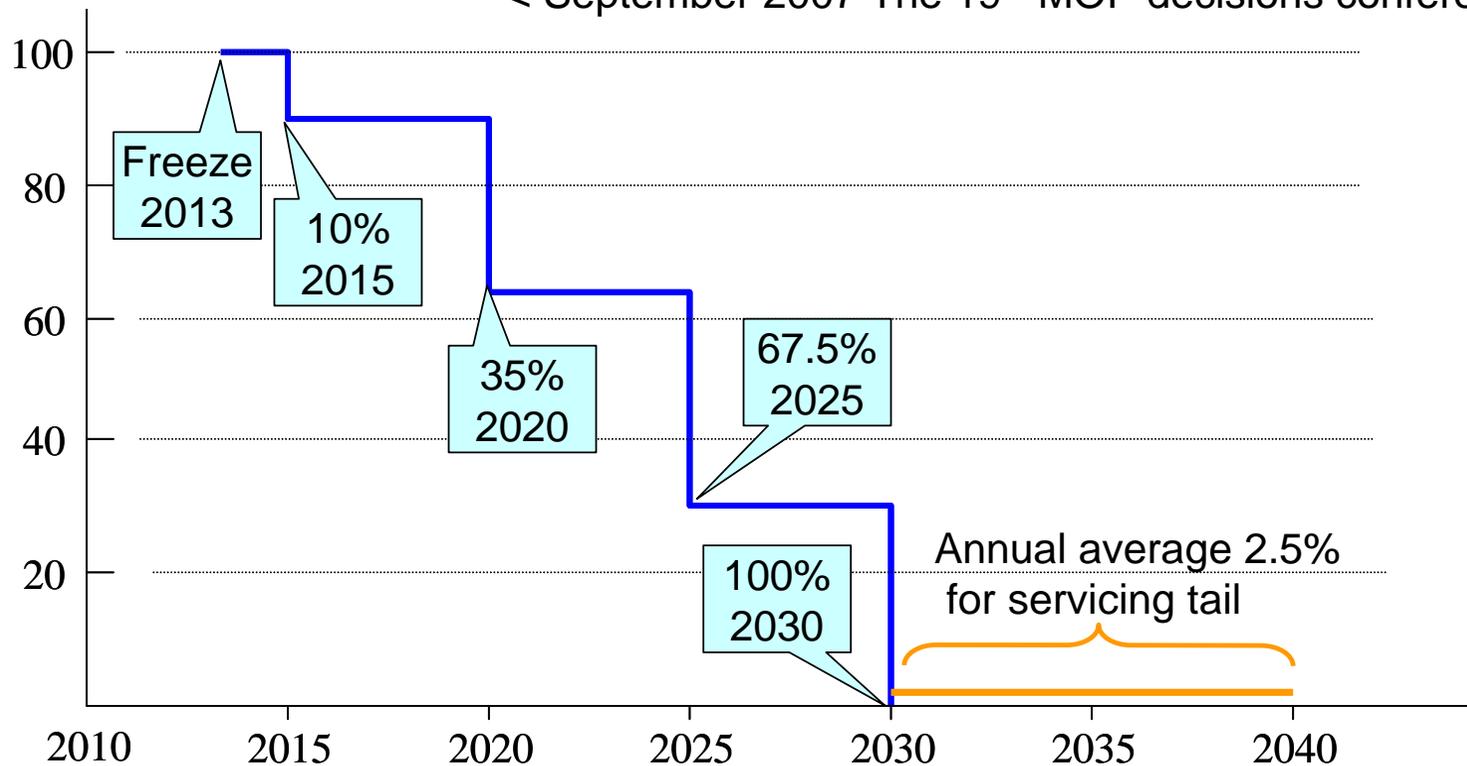
HCFC phase-out in each Asia-Oceania countries⁸

- Based on (see below) decisions of UNEP for emerging countries in ASEAN region, each countries are under making the concretely HCFC phase out plan (HPMP) and submit to UNEP

HPMP=**HCFC Phase out Management Program**

- HPMP implement of each countries are in next page

< September 2007 The 19th MOP decisions conference >



HPMP in each Asia-Oceania countries -1/2

	Direction (mainly from HPMP)	Fund executive organization
Thai	<ul style="list-style-type: none"> ▪ HPMP, using R410A, is rejected by UN (Apr 2012) ⇒ ▪ Re-propose to use R32 (Jul 2012) ⇒ Continue discussion on Dec, approved ▪ <u>HCFC import quota regulations start from 1 Jan 2013</u> (85% of 2009~2011's actual) ▪ Implement pilot P/J by 12 local maker from 2013~2018 ▪ METI supports local maker in cooperation with Japanese companies ▪ Revise law and regulations for R32 within end of 2014 ▪ <u>Local production ▪ import of R22 used RA model for domestic market is prohibit from Jan 2017</u> 	World Bank

◇ Breakdown of approved fund

Categories		Amount (MUS\$)
Foam		11.72
A/C	M/C conversion	8.35
	H/E conversion	0.52
	Technical support	0.08
	R32 compressor	0.25
	JP-TH technical support	0.30
(sub total)		9.50
Commercial refrigerator		0.45
Project promotion		1.38
Total		23.05

- Total 23MUS\$
- For A/C 9.5M\$
- JP-TH technical support 0.3M\$
← Can be apply for dispatch of lecturer

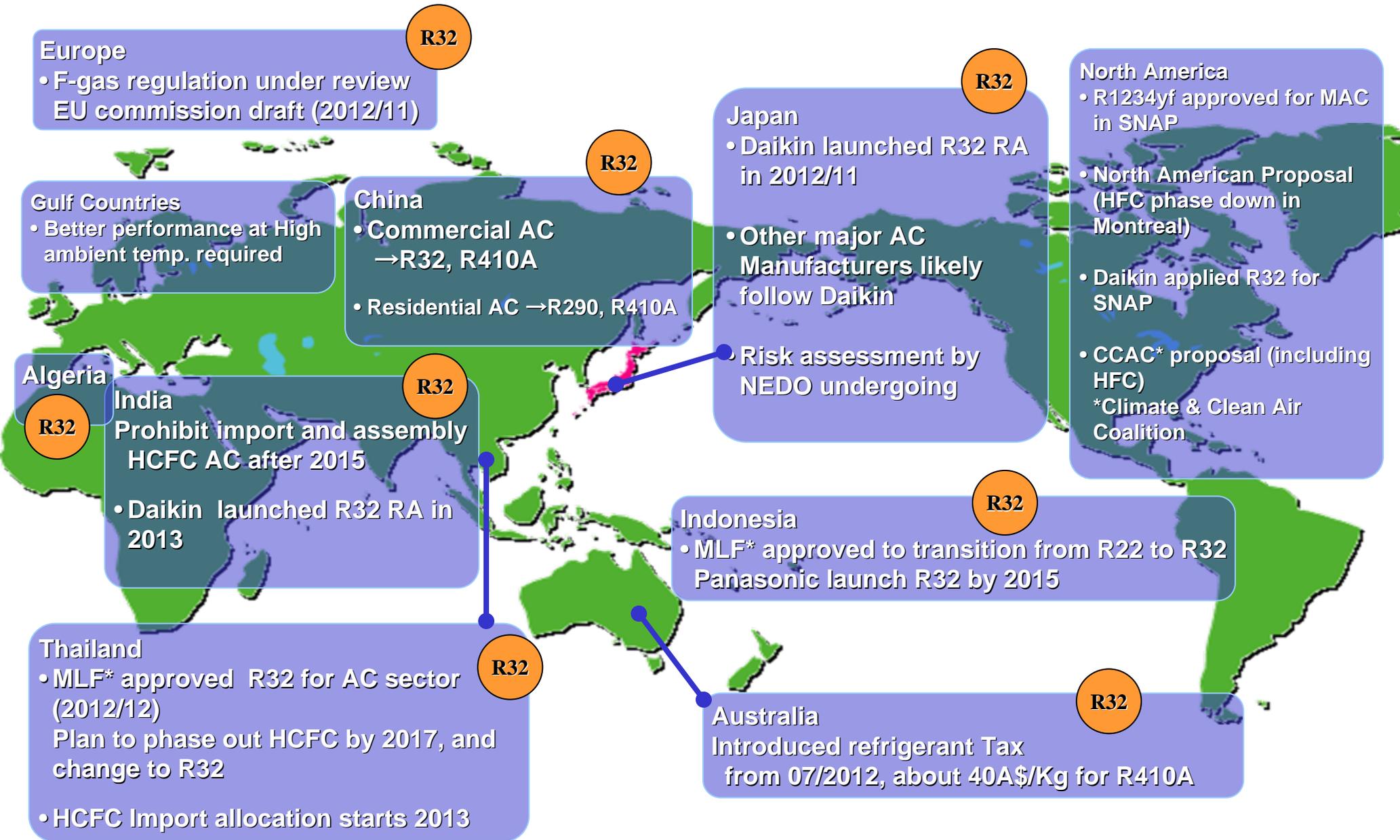
Hereafter

- ① Conclusion of the Memorandum of Understanding with concerned;
(Thai government, Local maker, Japanese government)
- ② Full scale operation Standard & Regulations working Gr etc.
Also take advantage from scene of the OEWG & Regional Mtg. and spread to neighboring countries
(Malaysia, Indonesia, Vietnam, Philippine)

HPMP in each Asia-Oceania countries -2/2

	Direction (mainly from HPMP)	Fund executive organization
Malaysia	<p>Stage I (2011 – 2015) is mainly for foam and service sector</p> <ul style="list-style-type: none"> ▪ Construction, enhancement of new production facilities for HCFC A/C is prohibit on 2013 ▪ <u>HCFC Import permission regulations start from 2013 (average from 2009–2010)</u> <p>Stage II (2015 – 2020) is completely reduction by A/C sector</p> <ul style="list-style-type: none"> ▪ <u>Production▪ Assy, import of HCFC A/C under 2.5HP is prohibit on 2015</u> ▪ <u>HCFC product production▪ Assy, import abolished totally in 2020</u> 	UNDP
Indonesia	<ul style="list-style-type: none"> ▪ Decided to apply R32 for A/C▪low temp. equipment sector ▪ <u>HCFC refrigerant import quota regulations established on 2012</u> ▪ <u>HCFC A/C production▪ Assy▪import are prohibit from 2015</u> ▪ Panasonic declares to launch R32 product to market from 2015 	UNDP
Vietnam	<ul style="list-style-type: none"> ▪ Implement from foaming agent and service sector, for A/C plan to start from 2016 	World Bank
Philippine	<ul style="list-style-type: none"> ▪ Implement from foaming agent and service sector, for A/C plan to start from 2016 	UNDP
Singapore	<ul style="list-style-type: none"> ▪ Already switching to R410A ▪ Follow to UN MOP conference resolution, without concretely plan announcement 	—
Australia	<ul style="list-style-type: none"> ▪ Already switching to R410A . Carbon dioxide emissions tax started on Jul 2012 	—
India	<ul style="list-style-type: none"> ▪ Start implement from foaming agent sector, for A/C plan to completed implement from 2015 ▪ <u>Plan to start HCFC import quota regulations from 2013, under discuss with government▪industries</u> ▪ <u>HCFC used A/C import is prohibit from 2015</u> ▪ <u>HCFC used A/C production totally abolish from 2020</u> 	UNDP

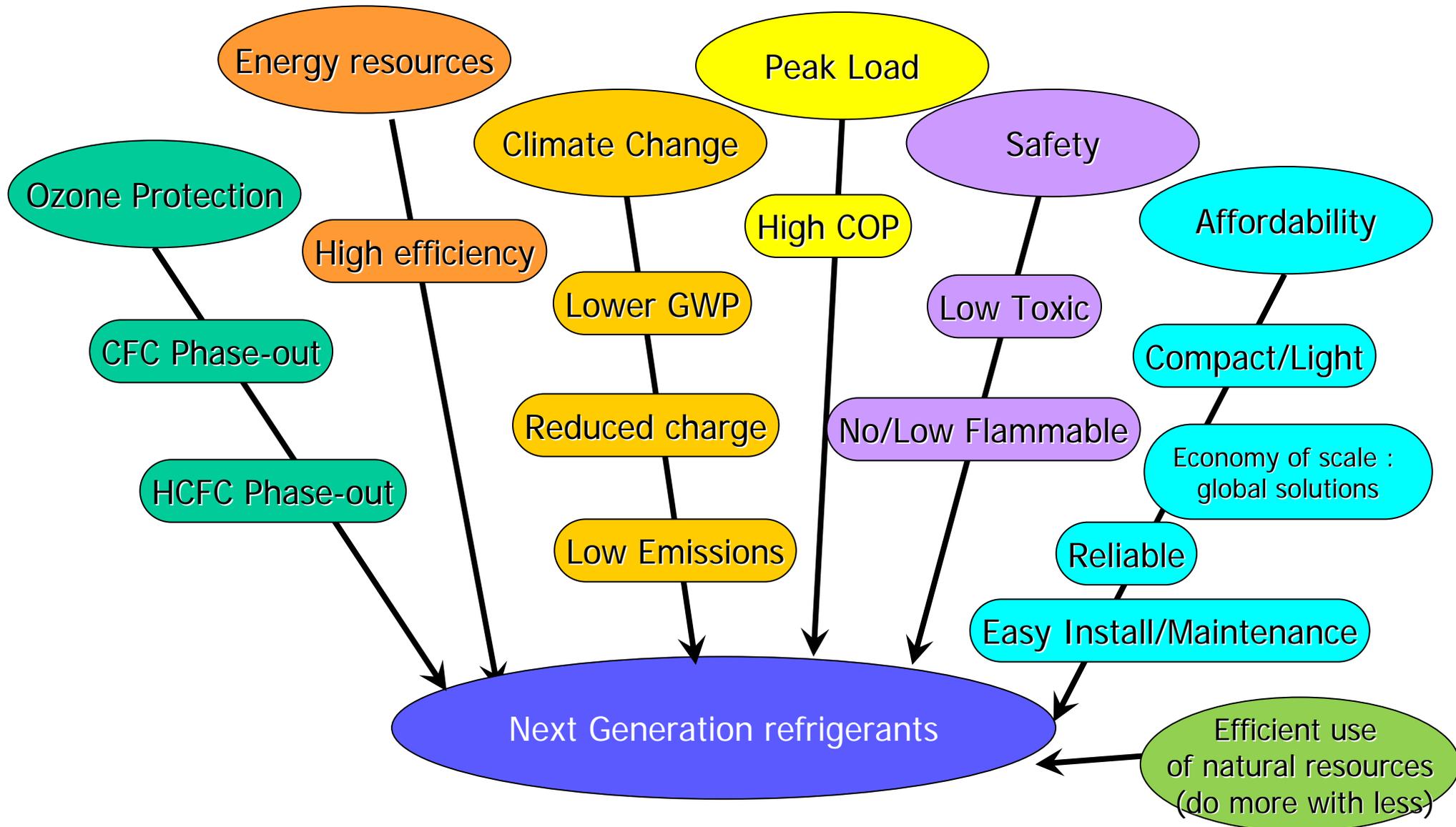
Brief Summary of Global Refrigerant Trend





How to choose refrigerant

Factors to Consider When Making a Choice



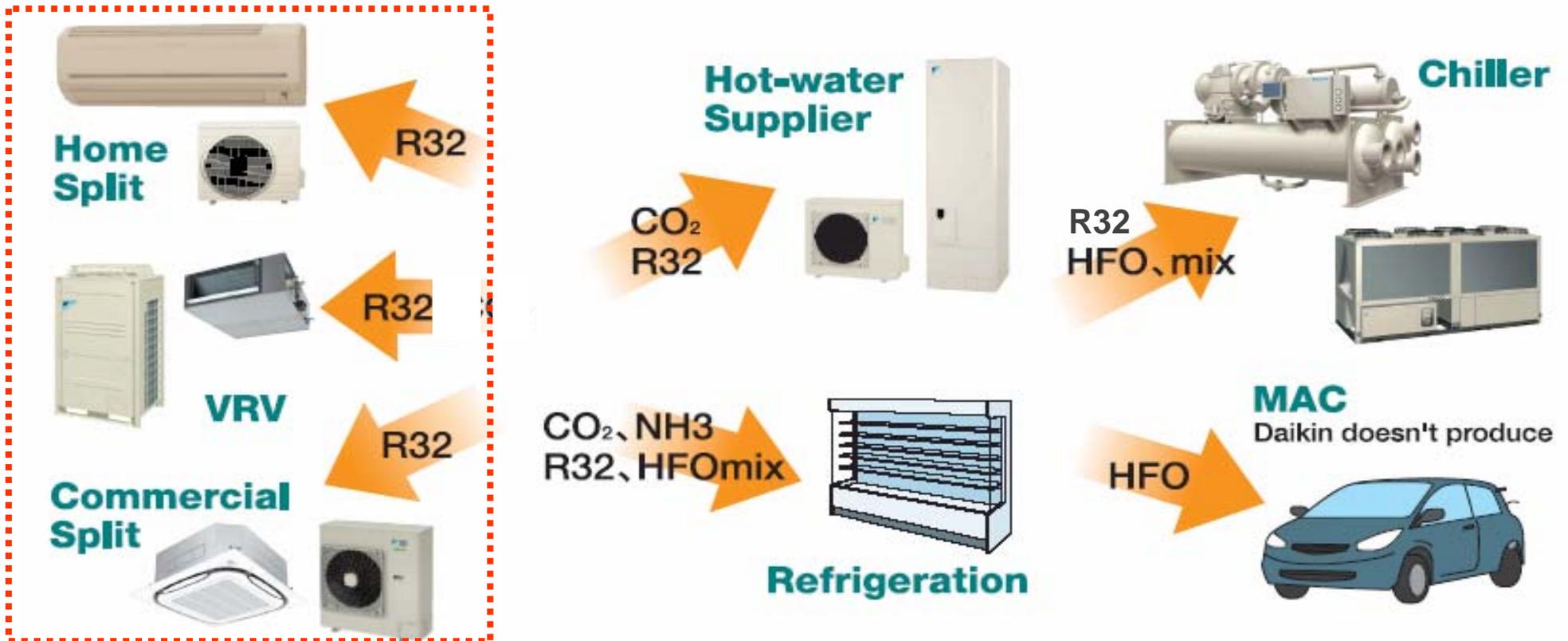
Refrigerant Candidates for stationary A/C

Refrigerants		Properties						
		ODP	GWP (IPCC4th)	P _{cond} (MPa)	Vol. Cool. Capacity (vs R22)	Theoretical COP (vs R22)	Flammability	Toxicity
HCFC R22		0.05	1810	1.73	100	100	Non	Low
HFC	R407C	0	1770	1.86	102	99	Non	Low
	R410A	0	2090	2.72	141	92	Non	Low
	R32	0	675	2.80	160	97	Low	Low
	R1234yf	0	4	1.16	57	90	Low	Low
	HFO-Mix	0	?	?	?	?	Low	Low
Non-HFC	R717(NH ₃)	0	0	1.78	116	106	Low	High
	R290 (Propane)	0	<3	1.53	83	98	High	Low
	R744 (CO ₂)	0	1	10	243	41	Non	Low

Candidates for the next generation working fluids

Diversity of refrigerant choice

- There is no one-size-fits-all solution.
- All refrigerant are included on the table of refrigerant choice
Choose whatever refrigerant is best suited for each application.
- Daikin is developing R32 split air –conditioners from residential to commercial range because R32 is better suited to these applications



R32 residential air-conditioner

Daikin launched R32 residential AC first in the world in 2012

Indoor Unit



Ururu
Sarara

Outdoor Unit

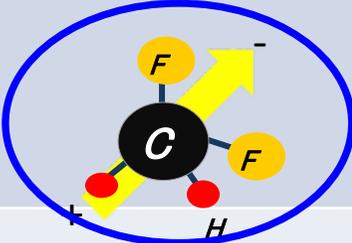
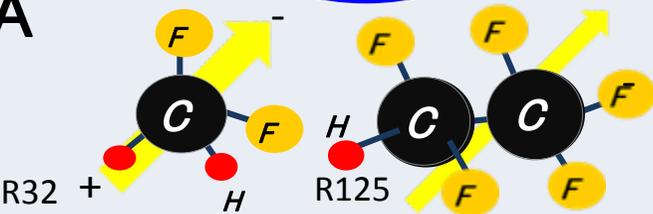
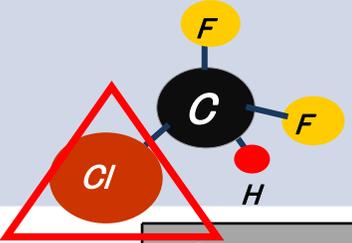


Award for highest energy efficient product in Japan



Superior Performance of R32

Refrigerant and Issues to be challenged for Environments

Refrigerants 冷媒	ODP (R11=1) オゾン破壊係数	GWP (IPCC4) 温暖化係数	Flammability (ASHRAE34) 燃焼性	Pressure [MPa,45degC] 圧力	Discharge Temp. (Te/Tc=5/45degC) 吐出温度	Refrigeration Oil 潤滑油
R32 	0	675	2L	2.79	75	Synthetic Oil 合成油
R410A 	0	2090	1	2.73	62	Synthetic Oil 合成油
R22 	0.055	1810	1	1.73	60	Mineral Oil 鉱物油

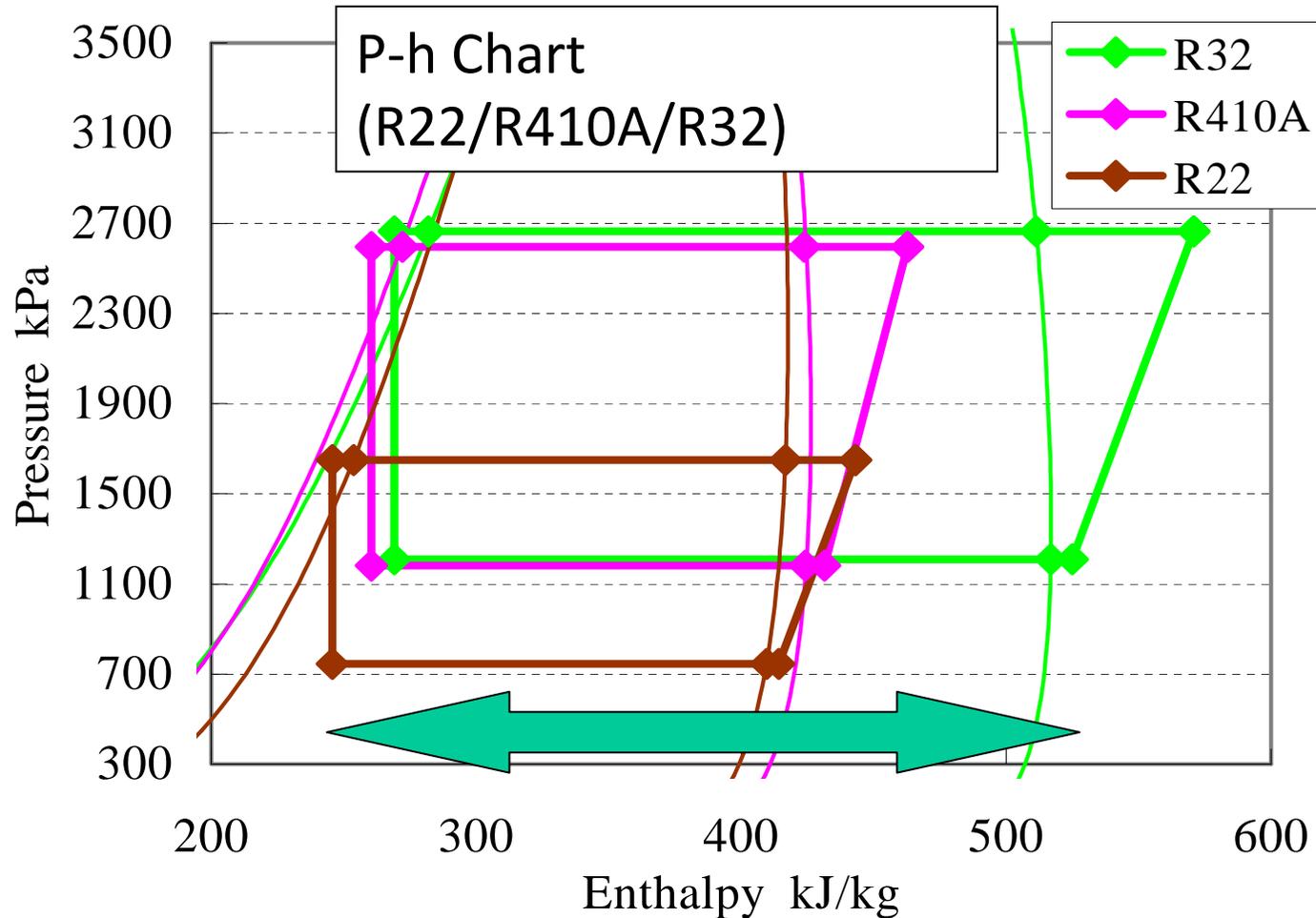
Property
Of each atom
各元素の属性

Atoms 原子	Advantage 長所	Disadvantage 短所
	Solubility with Mineral Oil 鉱物油との溶解性	Ozone Depletion オゾン層破壊
	Anti-Combustible 消火性	Higher GWP 高GWP
	Lower GWP 低GWP High Performance 高性能	Combustible 燃焼性

Each issue
to be solved
個別課題に対応

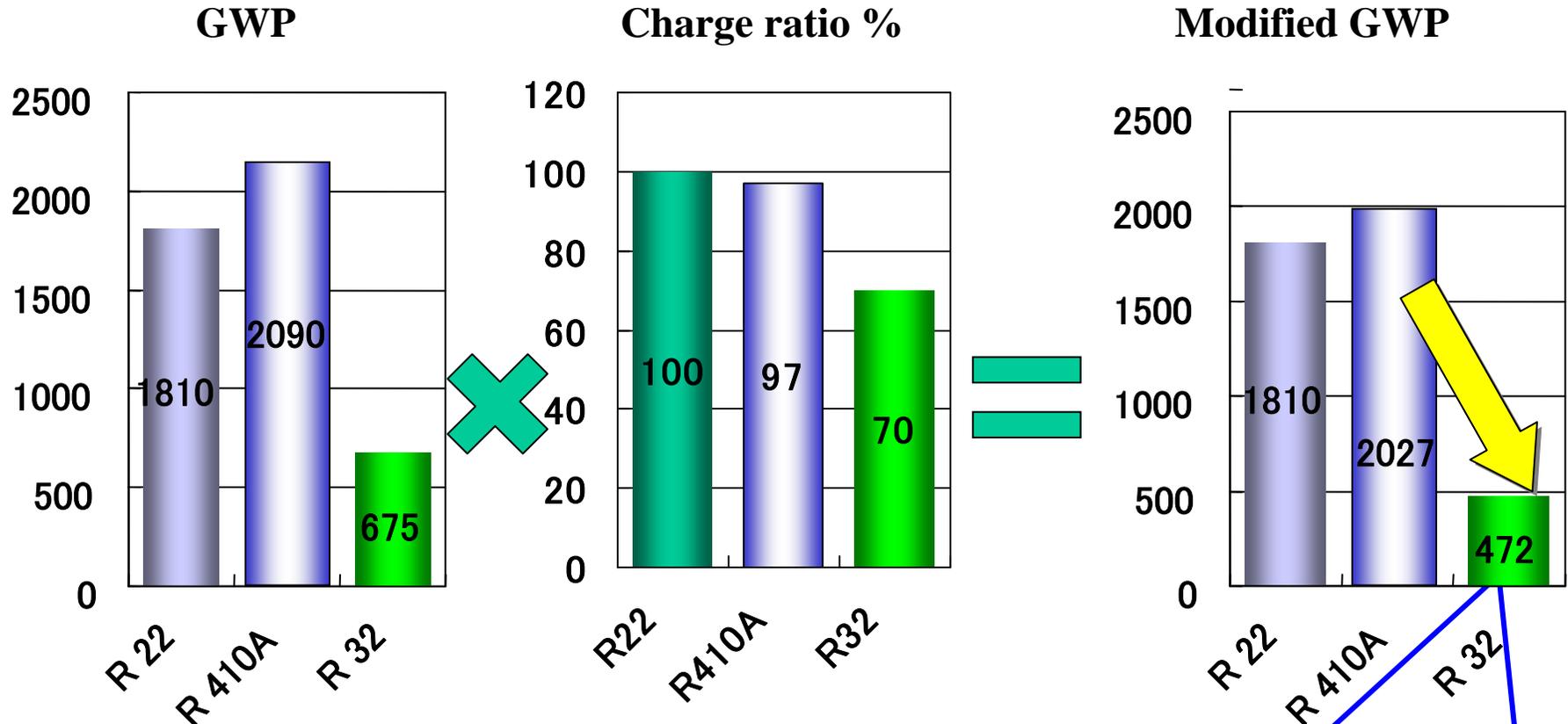
Comparison of cycles of refrigerants

Refrigerating effect of R32 increases 1.6 times to R22 or R410A



R32 can Reduce Direct Impact

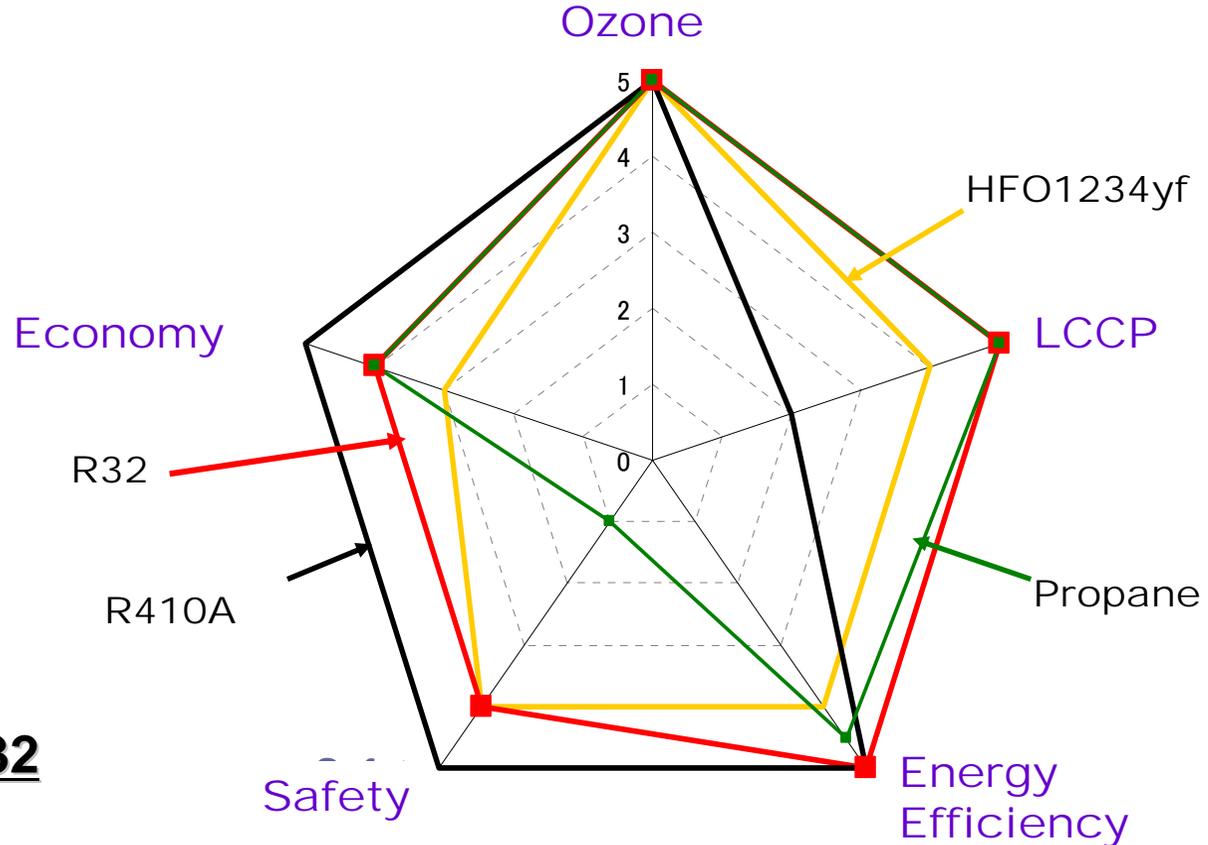
R 32 has the benefits of favorable GWP and reduced charge size



GWP values are based on IPCC4th report.

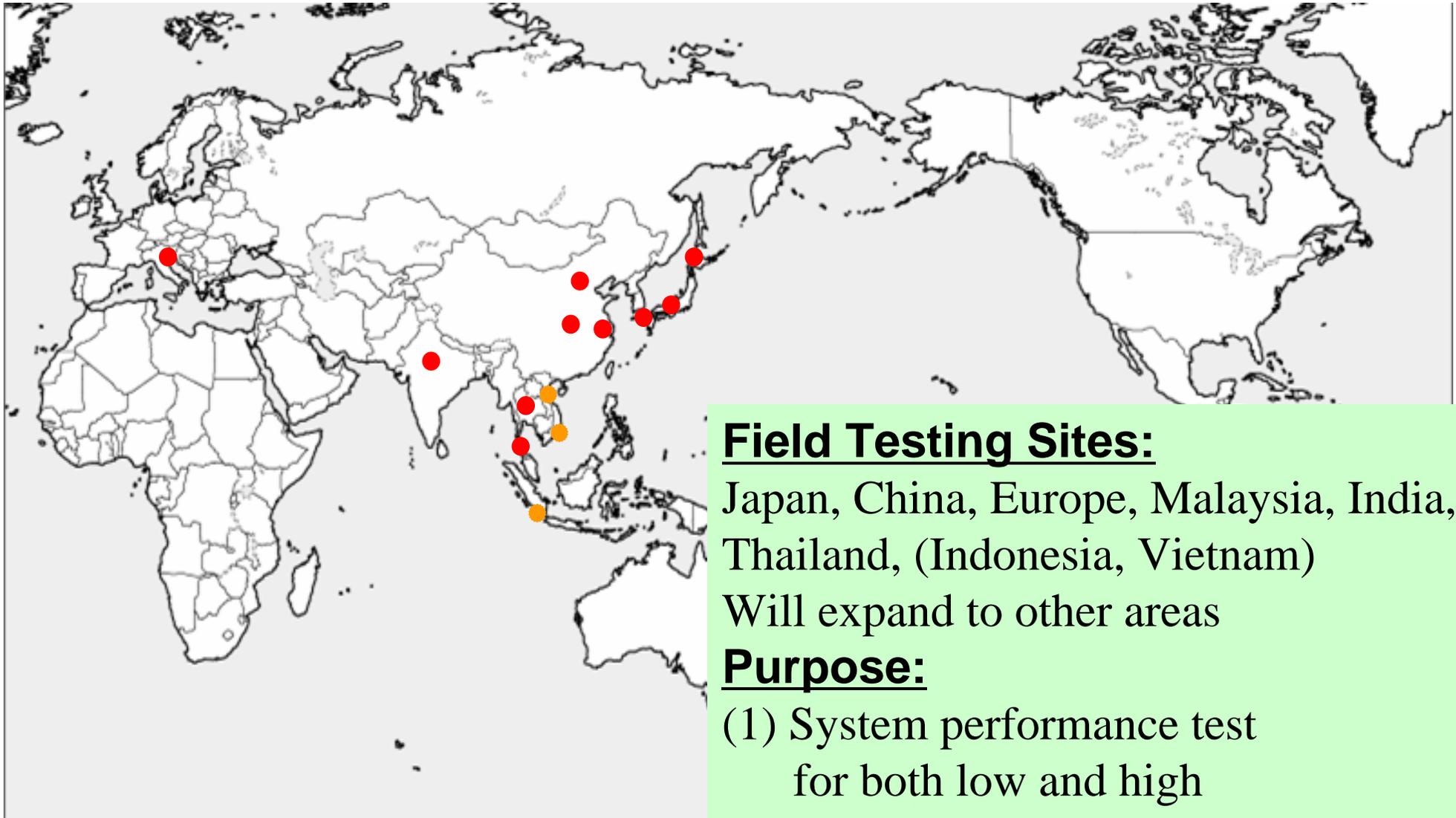
R32 can reduce CO2 eq. emissions by 75%

R32 is the Most Balanced



Characteristics of R32

- **Zero ODP**
- **Superior Energy Efficiency** (10% better than R22)
- **Small Global Warming Impact (LCCP; Life Cycle Climate Performance)**
- **Small Conversion Cost** (almost same as conversion to R410A)
- **Safety**, Acceptably Flammable (Class A2L)
- **Supply capability is sufficient** (Suppliers exist now)



Field Testing Sites:

Japan, China, Europe, Malaysia, India, Thailand, (Indonesia, Vietnam)

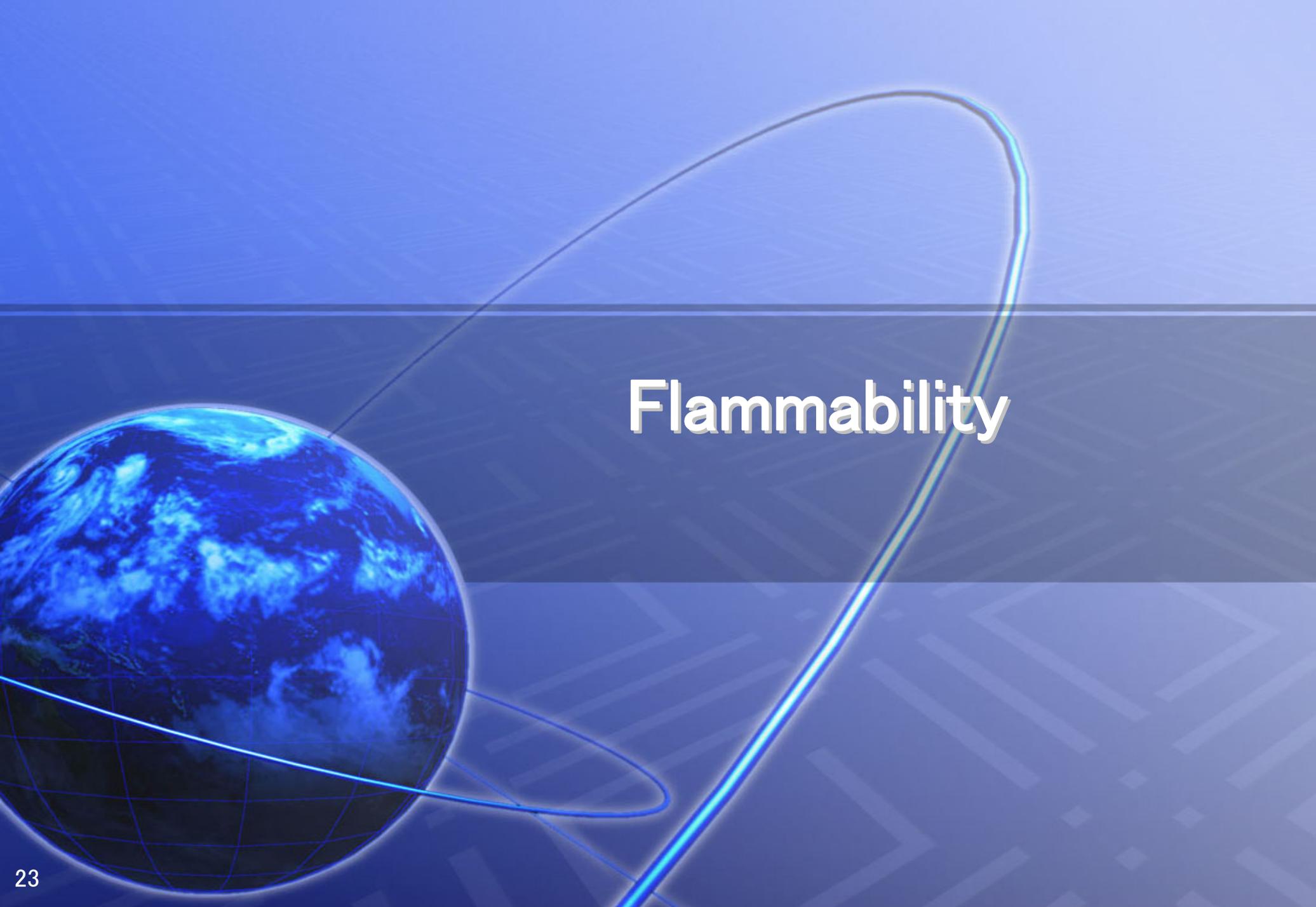
Will expand to other areas

Purpose:

(1) System performance test for both low and high ambient temp.

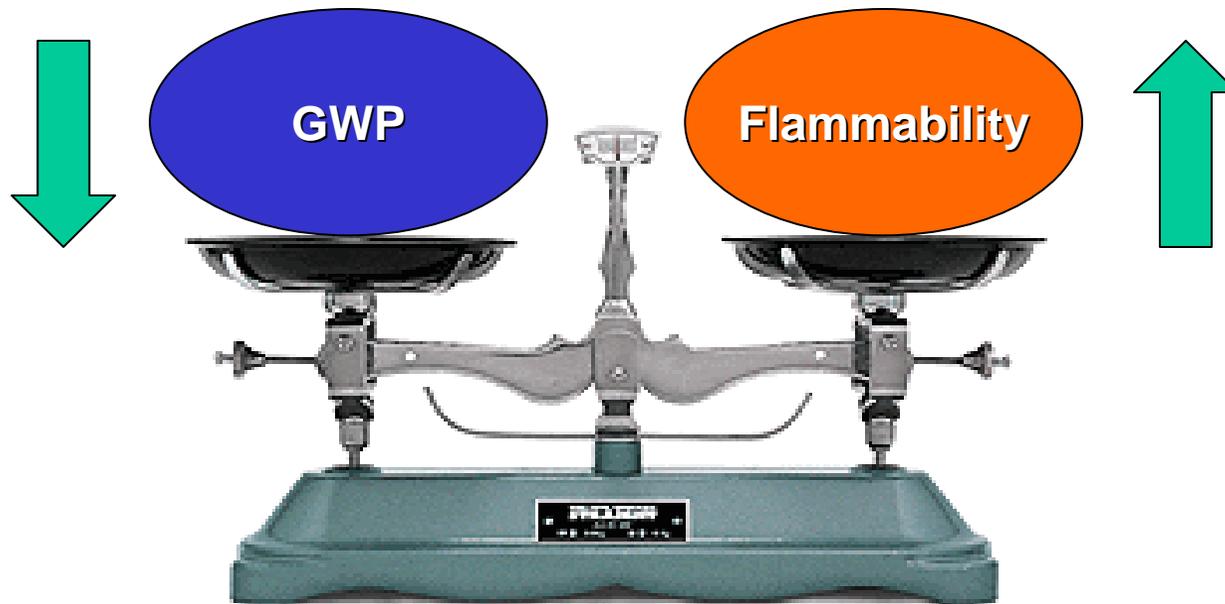
(2) Training contents preparation

Flammability

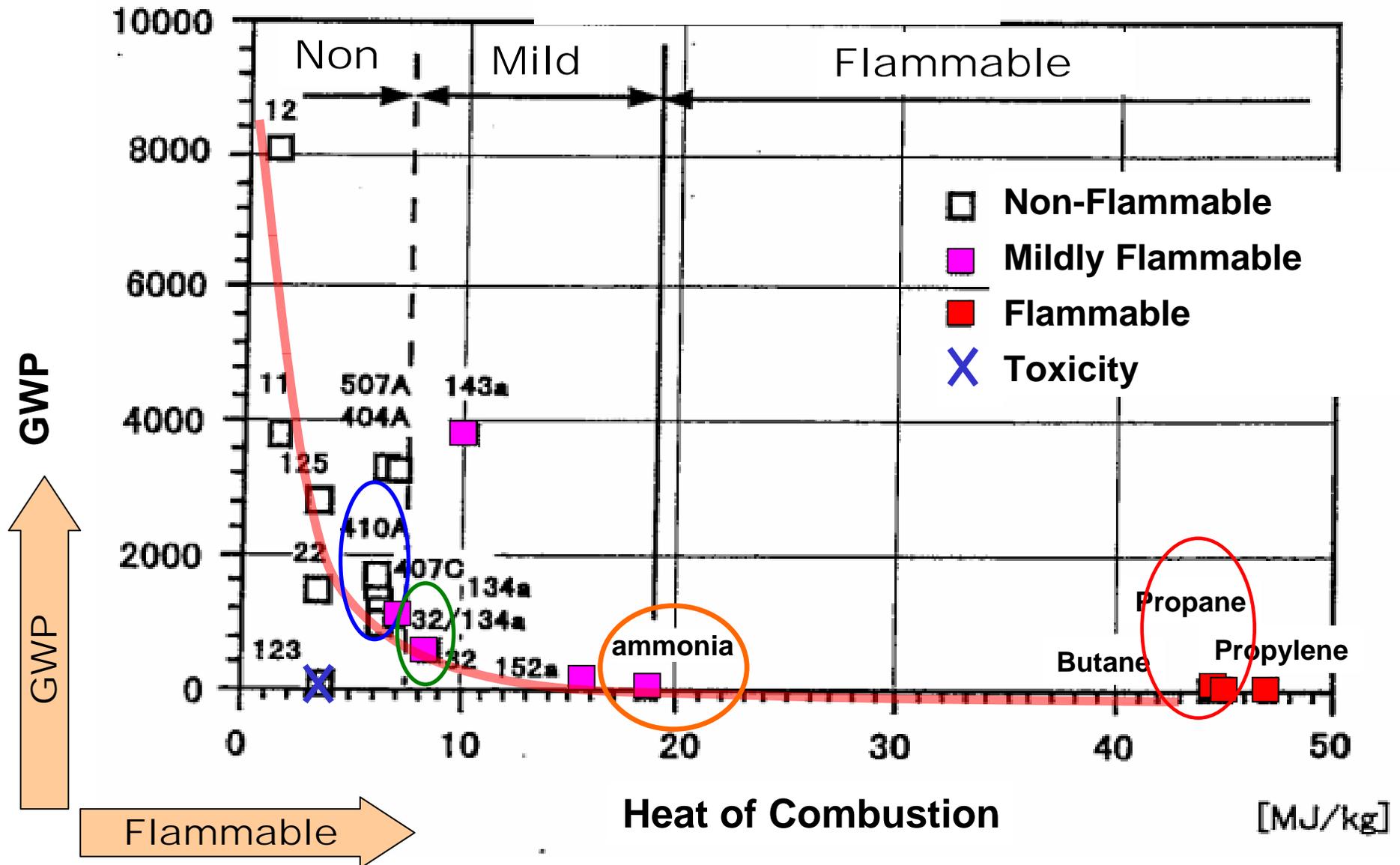


Flammability issue of Refrigerant

- Trade Off relation between **GWP** and **Flammability**
- Unavoidable physical and chemical phenomena



Risk Tradeoff of refrigerant



Safety Comparison

2L classification by ASHRAE

Class	Class 1 No Flammable	Low flammable		Class 3 Higher flammable
		Class 2L Burning Velocity (≤ 10 cm/s)	Class 2	
Example	CO2 R410A R22	R32 R1234yf Ammonia (higher toxic)	R152a	Propane

The burning velocity (<10cm/s) is too slow to cause horizontal flame propagation nor explosion.

Evaluated after long discussion & test in ASHRAE

Flammability of **2L** refrigerants is very mild.

R32 is Safe?

Risk Assessment of R32 by AHRI (Industrial Association in USA)

Results of Assessment of R32 Residential AC (AHRI Project 8004 Final Report 2012)

Incident Scenario	Probability Event/Unit/Year
Ignition in outdoor part of unit	9×10^{-5}
Ignition in room providing return air	3×10^{-14}
Ignition inside wall	3×10^{-14}
Ignition in room due to leak through duct	9×10^{-16}
Ignition within air handler	5×10^{-12}
Ignition during service	5×10^{-10}

mainly caused by failure of electrical feed through plug

But the following thing is described "i.e., no failures were observed in this timeframe so it constitutes a worst-case failure estimate"

Such as R32,R1234yf etc.

Conclusion: **described**

"The risks associated with the use of any of these ASHRAE 2L refrigerants are significantly lower than the risks of common hazard events associated with other causes and also well below risks commonly accepted by the public in general"

R32 is Safe ?

Risk Assessment of R32 by JRAIA (Industrial Association in Japan)

Results of Assessment of R32 Residential AC

(JRAIA INTERNATIONAL SYMPOSIUM 2012, and)

Incident Scenario	Probability Event/Unit/Year
Ignition during Logistic	$3.3 \times 10^{-19} \sim 4.6 \times 10^{-16}$
Ignition during Installation	$4.3 \times 10^{-11} \sim 3.2 \times 10^{-10}$
Ignition during Use	$5.7 \times 10^{-15} \sim 1.1 \times 10^{-10}$
Ignition during Service	$1.7 \times 10^{-10} \sim 4.0 \times 10^{-10}$
Ignition during Disposal	3.3×10^{-10}

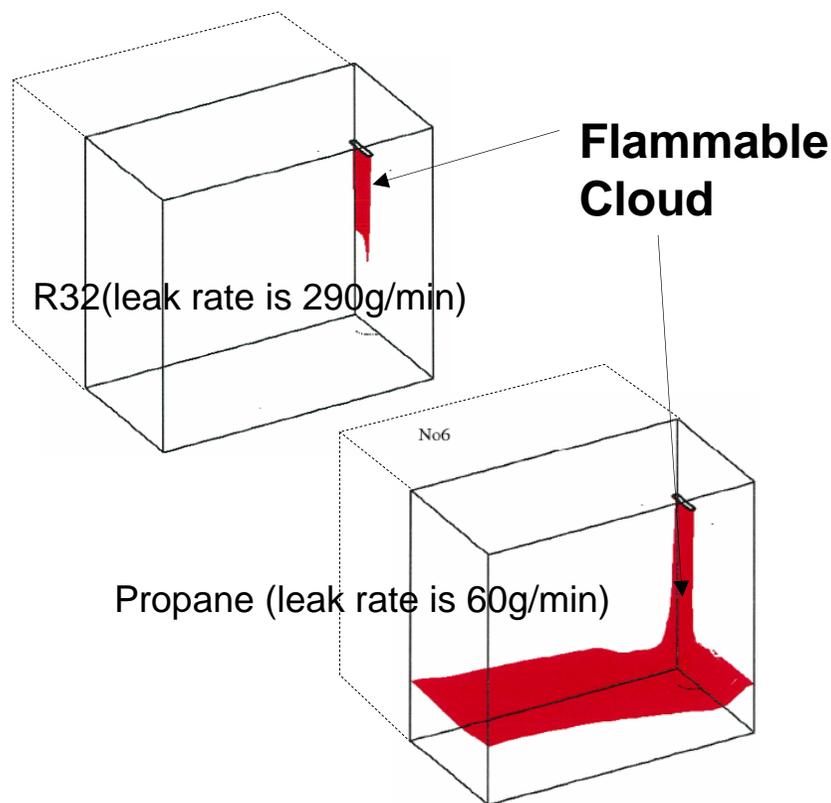
Conclusion: **described**
JRAIA confirmed the risk of the residential AC
using R32 is very safe during use.

It is confirmed
 by Tokyo Univ. of Science
 that cigarette lighter
 cannot ignite R32

Hard to ignite R32

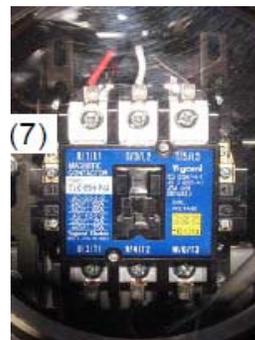
1. Flammable concentration (LFL) is high

(R32 is 14.4%、Propane is 2.1%)



2. To ignite R32, large energy of igniter is needed

- Small electrical switch cannot ignite



Electric Contactor under 240V, 50A cannot ignite R32.
(AIST; Governmental lab.)

- Cigarette lighter cannot ignite R32
(Tokyo Univ. of Science)

Very small flame

After 1/30second.

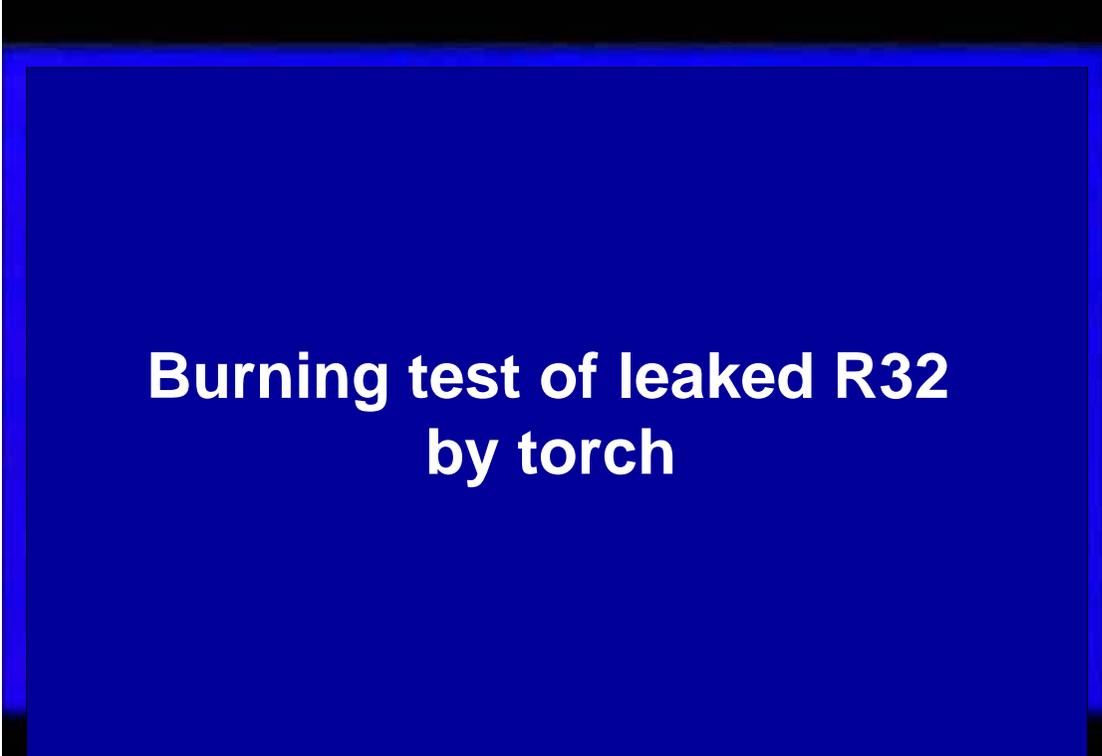


Why the risk of R32 is so small ?

Hard to ignite R32

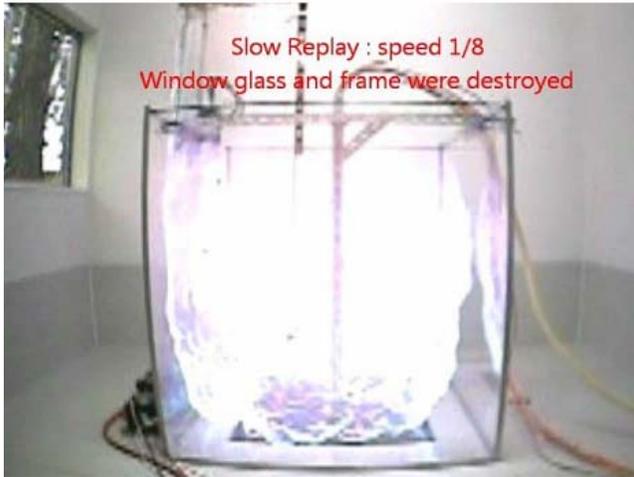
3. Easy to blow out due to low burning velocity

- A kind of torch cannot ignite R32



**Burning test of leaked R32
by torch**

Ignition Test for Extreme Condition



R290(propene)
30g in 1m cubic box

Exploded by electric spark

Class 3
Higher flammable



R32
320g in 1m cubic box

Ignited by open flame

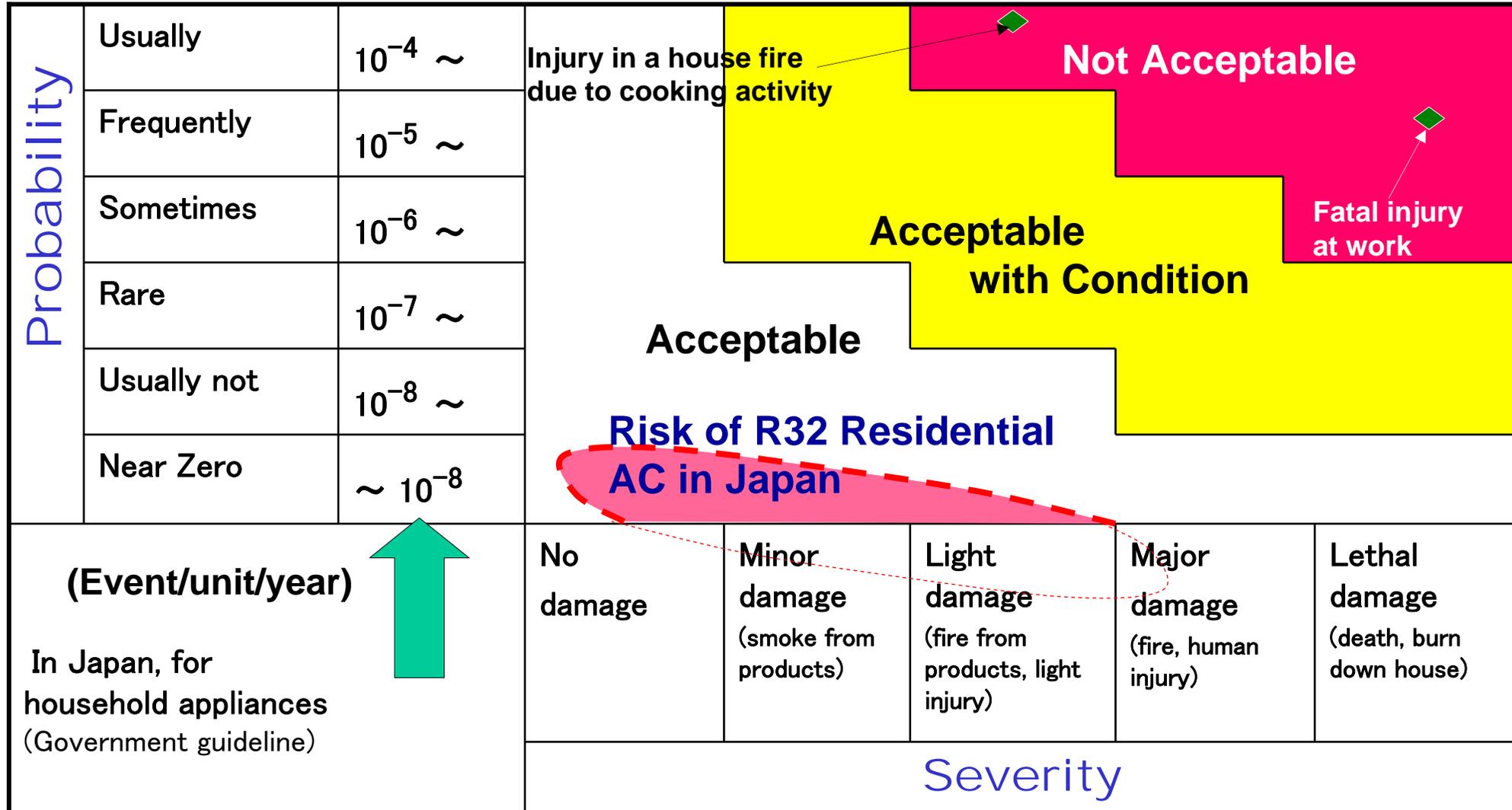
Class 2L
Slightly flammable



R1234yf
180g in 1m cubic box

Ignited by open flame

R32 is acceptable at the general point in R-map





Barriers & technology converting for R32

Barriers for R32

1. R32 gas distribution

- R32 is existing gas, not on the market as single component refrigerant, now.

2. Service infrastructure building

- AC should be installed by local installers.
- Training of installers with adequate service tools and a manual is necessary.

3. Local regulation

- No local regulations have not reflected A2L category in themselves just yet. So Inevitably R32 is handled as "extremely flammable "at present. Unnecessarily heavy investment and over-protections are requested.
- Earliest calling in of A2L with adequate handling standards to local regulation would be desirable.

	Manufacturing	Storages	Transport	Installation	Disposal
Life Stage					
Regulation	Severe explosion protection	Limited volume Storage	Limited load capacity	Strictly Certified service personnel	Severe explosion protection

Your support to remove the barriers will facilitate to prevail R32 in your countries.

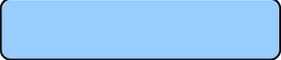
Technical Seminar of R32 in India

35

- Intended participants
- Air conditioner installation engineers
- Time required : Approx 3hours
- Number of seminar Approx : 75 times
- Targeted total number of participants : 3,500
- Funded by METI



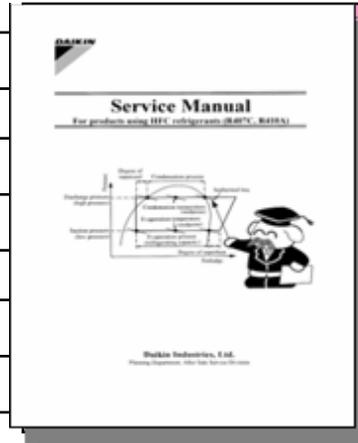
Service tool compatibility

Tools (*)	R32	R410A	R22
(1) Gauge manifold 	Compatible		
(2) Charging hose 	Compatible		
(3) Scale 	Compatible		
(4) Pipe bender 	Compatible		
(5) Flare tool 	Compatible		
(6) Torque wrench 	Compatible		
(7) Pipe cutter 	Compatible		
(8) Cylinder adaptor 	Compatible		
(9) Vacuum pump 	Compatible		
(10) Refrigerant recovery unit 	Compatible		
(11) Refrigerant recovery cylinder 	Compatible		
(12) Electric gas leak detector 	Compatible		

Note : May have some restriction on usage due to local regulations

Contents of Training

Seminar item 研修項目	General Attendees 一般参加者	Trained Attendees of R410A R410A技能者
R32 equipment outline R32の概要		
• Comparison of R32, R410A, and R22 models	✓	✓
• Refrigerant piping materials	✓	
R32 refrigerant characteristics 冷媒の特性		
• Comparison of R32, R410A, and R22	✓	✓
• Low flammability of R32	✓	✓
R32 refrigerant oil characteristics 冷凍油の特性		
• Comparison of refrigerating machine oil types	✓	✓
R32 refrigerant cylinder Introduction 冷媒シリンダ		
• Specifications of refrigerant cylinder	✓	✓
• Handling of refrigerant cylinder	✓	✓
R32 Service tools サービスツール		
• Tool compatibility	✓	
• Reason for tool change	✓	
• Tool introduction	✓	
R32 installation and service (with refrigerant change) 据付とサービス(冷媒交換)		
• Three principles for refrigerant piping (moisture and contamination control)	✓	
• Various types of work	✓	
• Troubleshooting	✓	
• Remarks	✓	✓



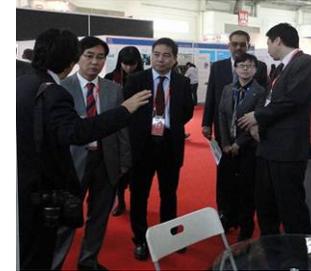
Potential Compressor Suppliers



Ozone2climate 2012/UNEP



Layout



DAIKIN



大連SANYO



GMCC



HITACHI



MITSUBISHI

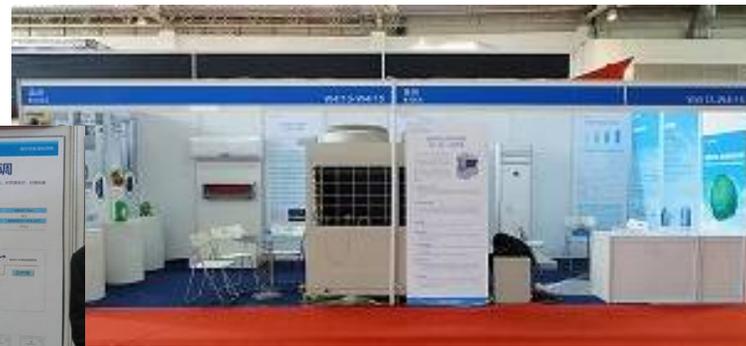


TICA(LOCAL)



GREE

HEIER



MEDIA

TONGFANG





Daikin will continue to make
further efforts to solve
environmental issues

We appreciate your
continuous support

Thank you for your attention.