

CHILLVENTA



Natural Refrigerants in China

by

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- **Introduction**
- **Water/R718**
- **Ammonia/R717**
- **Hydrocarbons---R290, R600a,R600**
- **Carbon dioxide/R744**
- **Prospects and challenges**

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Introduction (1/6)

➤ Vienna Convention for Protection of the Ozone Layer, **COP10**

1985-3-12 → 1988.9.22

197 Contracting Parties

- **China**, 1989-9-11 → 12-10
- 2015-9-16



30 Anniversary for VCPOL & International Ozone Layer Protection Day
by Ministry of Environmental Protection of the People's Republic of China

(http://www.zhb.gov.cn/zhxx/hjyw/201509/t20150917_309873.htm)

➤ Montreal Protocol

1987-9 24 → over **191** Contracting Parties

- **China**, 1991-6
- 2013.9.14 → 2030, Phase out HCFCs

2015, **COP27** Conference Parties (Dubai, 11.1-5)

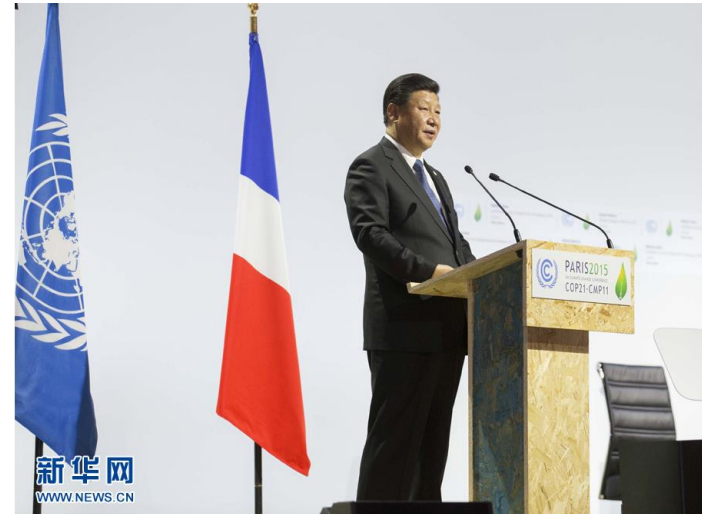
“China has phased out **58 thousand tons** of **HCFCs** in production, and **45 thousand tons** of **HCFCs** in consumption by closing and reforming the production lines of HCFCs.” announced by Qing Zhai, vice minister of Ministry of Environmental Protection of the People’s Republic of China.

Introduction (1/6)

- **Kyoto Protocol, COP11** (under United Nations Framework Convention on Climate Change/UNFCCC, **COP21**)
1997-12 84 → **195** Contracting Parties
- **China**, 1998-5 → 2002-8

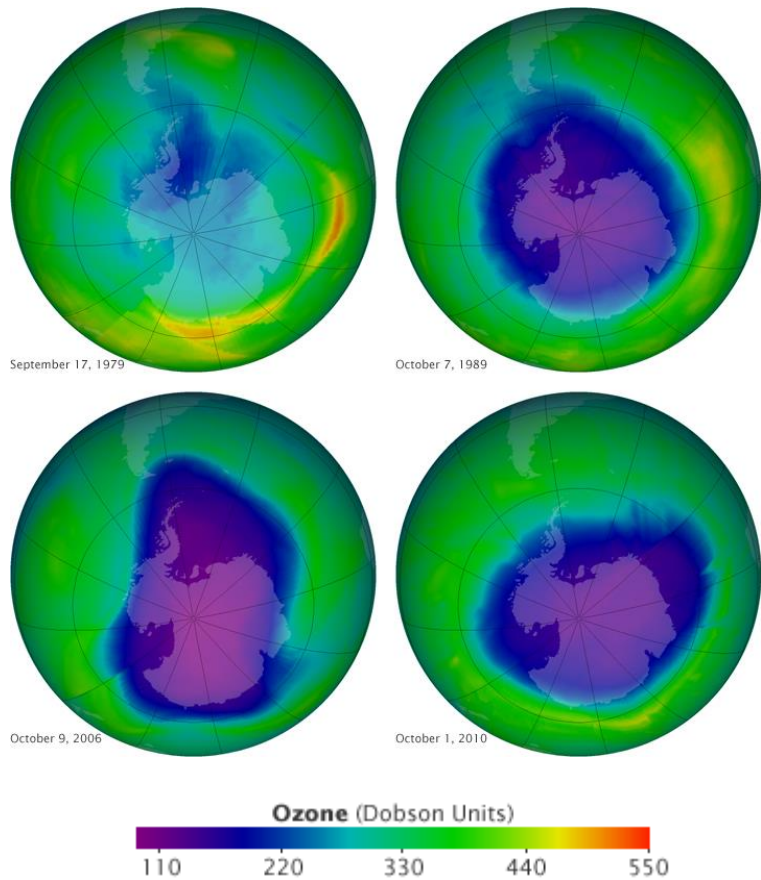


1997 UN Climate Summit (Kyoto, 12-9)
(<http://baike.baidu.com>)



2015 UN Climate Summit (Paris, 11-30)
(<http://www.xinhuanet.com/world/bldh/index.htm>)

Introduction (1/6)



Antarctic Ozone Hole (NASA)

Antarctic Ozone Hole Size (NASA, NOAA)
10⁶ km²

Year	Date	Max	Mean 7 Sep -13 Oct
1979	17 Sep	1.1	0.1
1989	03 Oct	21.9	18.7
2006	24 Sep	29.6	26.6
2010	25 Sep	22.6	19.4
2014	11 Sep	24.1	20.9
2015	02 Oct	28.2	25.6

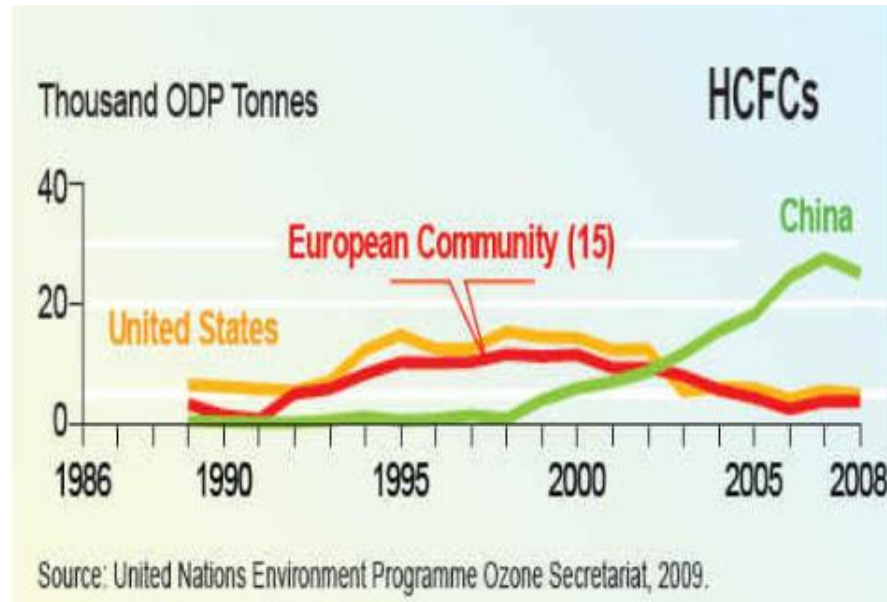
Introduction (1/6)

➤ 2007.7.1----No production & import of CFCs

House Refrigerator, 54 reform production line, 13087 tonnes

Automobile, 15 reform production line, 1659 tonnes

➤ However



Production of HCFCs

(<http://www.theozonehole.com/cfc.htm>)

Introduction (1/6)



- 1989-2030** the total **estimated** emission of HCFCs 22
- 3.36 million tonnes
 - equivalent ODP 160 thousand tonnes
 - 6.0 billion tonnes

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LiBr Absorption Refrigerating





LiBr Absorption Refrigerating

- Late 1980s--- **Quick** development due to the power shortage
 - More ads on CCTV on LiBr Absorption Refrigerator
 - Comfort Central Air Conditioning
- Since 2000--- **Retardant** development
 - Relatively sufficient power supply
 - High price of oil, gas
 - Debate on efficiency, energy-saving
- Industrial Air Conditioning with available **waste heat**



LiBr Absorption Refrigerator

- 1966 → the first steam-driven one-effect unit made by China
- Since late 1980s → More than 100 manufacturer including Sino-foreign joint ventures
 - Rank among the best on **manufacturing level** and **large-scale unit production**
- Now → nearly 10 manufacturer with **all core technology**
- International market → Middle East, West Asia rich in gas or oil, Japan, Spain, Thailand, USA

Direct-fired LiBr Absorption Refrigerator





Research on LiBr Absorption Refrigerating focuses on:

- **Solar** absorption refrigeration
- Double-effect absorption refrigeration cycle
- Efficient absorption type cold and hot water unit
- Absorption refrigerator using low temperature heat source
- Absorption heat pump using **waste heat**

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Commercial, Industrial



Cold storage

Commercial, Industrial

- Before 1950 → Cold storage, Manual adjustment
- Since 1950 → **Large and medium scale** cold storage, Brewery, Chemical plant, Pharmaceutical factory
- 1970s-1980s → Automatic control and system
- Before 1980s → Shell-and-tube heat exchanger
- Since 1990s → Evaporation condenser
- 2000 → **Electronic expansion valve** used at a Aquatic Products Processing Plant in Dalian, Liaoning Province

Commercial, Industrial

- By 2014 → **23 thousand Enterprises** using R717 refrigerating
 - 16% large scale
 - 7% with a R717 storage capacity over 10 tons
- **Large and medium scale refrigerating system** → Dominant
- Past few years → Rapid development on infrastructure
construction of cold chain accelerated
by fresh food E-commerce
- **Security threat** both in management and equipments →
large refrigerant charge





Ammonia Refrigeration Equipment

- Significant development → Import substitution by independent brands
- **Compressor** → Shortened gap between China and developed country
- Key enterprises → GEA, Carbero Heat Exchanger, Yantai Moon Group etc.



Rich application experience VS **poor** theory and comprehensive research

Focuses on:

- Safety technology on application
- System design

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Hydrocarbons---R290, R600a, R600 (4/6)

Propane/R290

- Zhuhai Gree Corporation → 4500 researchers, 300 labs

2007.1-2008.12 Research, Product

Replace R22 with R290 in **space air conditioner**

EER rises by 15%

2009 GIZ, 1050 thousand Euros donation

10 thousand units per year

2010.9 German VDE Certification



Hydrocarbons---R290, R600a, R600 (4/6)

Propane/R290

- 2011.7 Sino-German **World's First** Demonstration Production line of R290 Split Air conditioner



Acceptance of the project (2011.7.14)

More than 10 patents
R290 compressor

Hydrocarbons---R290, R600a, R600 (4/6)

Propane/R290

Midea → 2010 Montreal Protocol Demonstration Project on the
first reform production line of R290 Air Conditioner



Acceptance of the project (2013.12.17)

China 3C
Europe ATEX, CB, CE
Australia SAA
International TUV

34 patents

Hydrocarbons---R290, R600a, R600 (4/6)

Propane/R290

GMCC---2006, Research under National 863 Program

2010, Montreal Protocol Demonstration Project on
R290 compressor for air conditioner

2013, Mass production for **air conditioner** and **heat pump**



Sign ceremony (2011.11)

Hydrocarbons---R290, R600a, R600 (4/6)

Propane/R290

2015. 4.08---Haier, supply R290 air conditioner

2015.4.30--- Gree, supply R290 air conditioner

Midea, Changhong



2015.6.28

China's production of air conditioner accounts for 75-78% in the world, of which nearly 45% is exported.

Propane/R290

TCL → Split Air Conditioner Prototype

Midea → R&D

Haier → R&D

Chigo → R&D

Industrial system needs **promoting**, including the introduction of mature European technology.

Propane/R290

Research focuses on:

- Heat exchanger
- Lubricant oil
- Air conditioning system
- Refrigerating system
- Explosion protection

Hydrocarbons---R290, R600a, R600 (4/6)

Isobutan/R600a--House refrigerator

1992 →Germany, FORON(DKK), 90%; Europe,25%

1993 →China, Kelon,**53%**

The number of refrigerator in China (10 thousand units)

Year	Production	Export	Domestic
2005	2987	1764	1223
2006	3500	1306	2194
2007	4250	1608	2642
2008	4590	1614	2976
2013	9340	2421/ 825 (1-8)	
2014	9337	2292	7045
2015	9159	3966	5193





Isobutan/R600a, Butane/R600

Research focuses on:

- Explosion protection
- Noise of compressor
- Lubricant oil system
- Maintenance
- R290/R600a mixture for house refrigerator
- R600a/R32, R600/R125, R744/R600 etc for auto-cascade refrigeration or heat pump

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Carbon dioxide/R744 (5/6)



- NH_3/CO_2 **Cascade** refrigeration---Shandong, Liaoning, Jiangsu, Gansu Province; Shanghai, Guangzhou etc.

Yantai Moon Group---since 2013

more than 40 projects:



Dalian Zhangzi Island Marine products processing center(2014)

the **sign** of scale industrial application of CO_2

- $\text{R507}/\text{CO}_2$ **Cascade** refrigeration---Chongqing (2013)

China Academy of Agricultural Science

Carbon dioxide/R744 (5/6)

- CO₂ transcritical cycle---Cold storage, Peking in 2013

Peking Jingkelun Engineering Co. LTD

- Supermarket ---Nanjing, Wuxi (Metro)

Carrier--- 20 cold storages, more than 160 display cabinets

- Heat Pump Water Heater

Carbon dioxide/R744 (5/6)

HPWH---Huiyuan, 2013; Haier,2014; Wanjiale, 2016



最高出热水温度 80°C
 外界温度 -25°C
 无温室效应 GWP1

38dB 超低噪音
 COP5.0 超高热效率

- ◆ 制热能力4.5KW
- ◆ 出水温度55-80°C
- ◆ 适用人数3-6人
- ◆ 全直流变频技术
- ◆ 搪瓷水箱抗腐

CO₂全直流变频热泵采暖机

最高出热水温度 70°C
 外界温度 -25°C
 无温室效应 GWP1

47dB 超低噪音
 COP4.3 超高热效率

- ◆ 制热能力3.5-11kW
- ◆ 出水温度45-70°C
- ◆ 适用面积80-130m²
- ◆ 全直流变频技术
- ◆ 地暖/暖气片

Carbon dioxide/R744 (5/6)

- 2015 Annual Conference of Chinese Association of Refrigeration
'CO₂ Refrigeration Technology' Symposium



Profesor Baomin Dai



Deputy Engineer Shaoming Jiang

(<http://news.ehvacr.com/news/2015/1118/97185.html>)

Carbon dioxide/R744 (5/6)



High expectation, relatively wide research VS Relatively **narrow** application

→ due to the pressure **4-6 times** higher than that of R22 and then the following high manufacturing cost, technology problems

Carbon dioxide/R744 (5/6)

- 1998 → Tianjin University, Research
- 2008 → GB/T23137-2008 *Heat pump water heater for household and similar application*
- 2010 → GB/T26181-2010 *Hermetic motor-compressors for household and similar heat pump water heater using CO₂ refrigerant*
Shanghai Hitachi, Xi'an Anqing, GMCC,
Midea (2009)
- 2015 → JB/T12326-2015 *Heat Exchanger for CO₂ Refrigeration System*

Carbon dioxide/R744 (5/6)

- Fewer manufacturer of Compressor, Expansion Valve
 - [Bingshan Group](#) on 2016 China Refrigeration Show in Peking
 - [Shenshi Heat Exchanger Co. LTD](#)
- Three times higher cost than the traditional one



Research focuses on:

- System performance of heat pump or cascade refrigerator
- Heat transfer characteristics and heat exchanger
- Optimum heat rejection pressure
- Reduce of pressure---mixture R744/R600, R744/R290
- Cycle

Others natural refrigerant



Dimethyl Ether/DME/RE170

Research stage

- Theoretical research on thermodynamic properties, combustion and explosion, system performance of heat pump or automobile air conditioner, oil solubility of DME
- Theoretical research on mixture: CO₂/DME, R125/DME, R1270/R227ea/DME, RE170/R227ea
- Fewer experimental research on thermodynamic properties

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Prospects and challenges (6/6)

1. Complete solution to refrigerant replacement
2. Codes or standards first

GB/T26181-2010

3. Government support
4. Financial and technological support
5. Wide international cooperation
6. Advanced and efficient management

Ammonia, CO₂



Thank you!

A background image showing several large, jagged icebergs floating in a dark blue ocean under a clear blue sky. The icebergs are white and have sharp, pointed peaks. The water is dark blue with some ripples.

eurammon is available as your sparring partner at any time when it comes to questions about refrigeration with natural refrigerants.

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