

Status of Natural Refrigerants in Indian Market

by

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Natural Refrigerants (IIT Kharagpur Survey)

AWARENESS

- All respondents: India would need to switch to natural refrigerants
- 72% agreed that India would need to leap frog over the use of HFCs directly to natural refrigerants
- A large majority (81%) even knew that solutions already existed
- 62% believed that CO2 based supermarket systems could become a reality in India

SPECIFIC BARRIERS

- Legislation (policies and standards)
- Refrigeration and safety engineering
- Supply and availability of components
- Systems and commercial reasons (investment, profit, financial incentives).
- Market barriers





GREATEST POTENTIAL

- Hotel industry and supermarkets
- Family-owned small fresh food stores would still hold the largest market share
- Air-conditioning in stores and cascade ammonia-CO2 refrigeration systems could promise a higher market penetration provided that global consumer brands would implement their natural refrigerant strategies in all world markets, including India



AC Market in India

- RAC Market
- Air-conditioning

Air-conditioning 77.5% Refrigeration 14% Service 8.5% Room A/C 36% Central Plants 22.5% Duct/Package 13%

- Annual Sales 4.2 million Room ACs (72 billion)
- Growth Rate Room ACs 25% 30% growth rate
 - Split Units 70%
 - Window Units 30%
- Refrigerants used
 F-gases (HCFCs or HFCs)



AC Market India in 2012

Summer 2012 Air conditioners Market Share in India

Manufacturer	From (%)	То (%)
Voltas	16-17	18.3
LG	22.6	17.7
Samsung	14.5	10
Panasonic	4.9	9.9
Hitachi	5.2	7.3



AC Market India in 2012

STRENGTHS: INDIAN MARKET

- Growing affuent middle class, robust economic growth coupled with booming retail sector will ensure of AC market growth of 25-30%
- Adoption of green technologies is taking off in Indian market
- High growth, concerns about distribution of perishable items and cold chain infra are driving parameters for RAC market

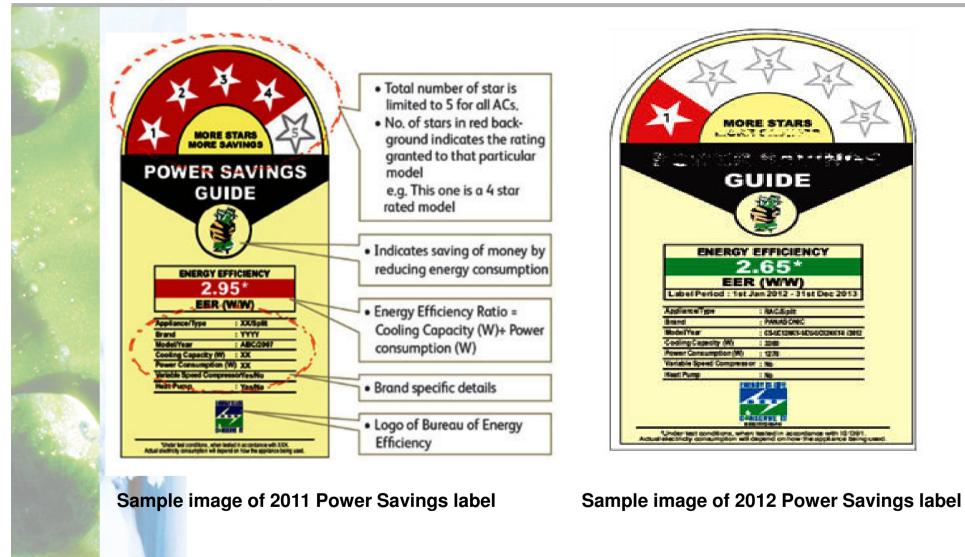


Indian AC Market : 2017

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 - Poised for greater growth over next 5 years
 - Expected CAGR 13.6% for next 5 years
 - Driving forces for growth of AC Market
 - Increasing cooling capacity with new technologies
 - Falling prices of air conditioners
 - Rising weather temperature
 - Increasing disposable income
 - India Air Conditioners Market Set to Cross INR 20,000 Crores by 2017
 - In 2009, it was about INR 10250 Crores



Energy Labeling: ACS





2012 STAR-EER Mapping for Split ACs

Star Rating	EER (W/W)			
	Min.	Max.		
1. Star	2.50	2.69		
2. Star	2.70	2.89		
3. Star	2.90	3.09		
4. Star	3.10	3.29		
5. Star	3.30			

- DOs and DON`Ts of Buyingan Energy Labelled Air-Conditioner
 - Check the cooling capacity of the Air Conditioner and its power consumed in Watts
 - Do not compromise on cooling capacity while choosing an Air Conditioner with a higher star rating
 - Always prefer a higher star rated Air Conditioner than a lower rated one. Although higher rated AC's are a bit more costly than lower rated ones, but the energy conservation that they provide will act as a profitable investment in the long run
 - Make a choice depending on the dimensions of the room and the cooling capacity needed while always preferring a higher star rated product



HCFCs and Applications

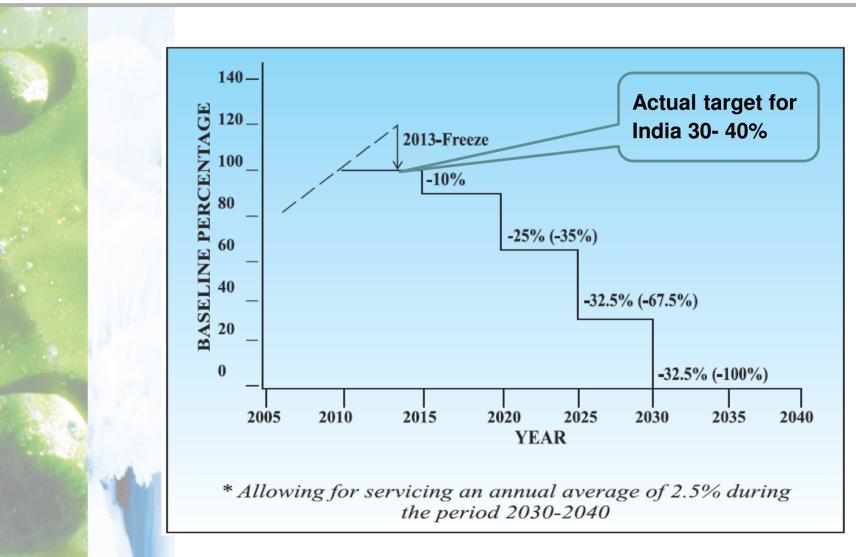
• HCFC-22

Refrigeration and Air Conditioning Sector

- HCFC-141b Blowing agent in the manufacture of rigid polyurethane, Aerosol, Foams
- HCFC-142b Extruded polystyrene foam
- HCFC-123 Large capacity centrifugal chillers
 - HCFC-124 Stationary Chillers, Blowing agent
 - HCFC-225

Solvent in precision cleaning applications



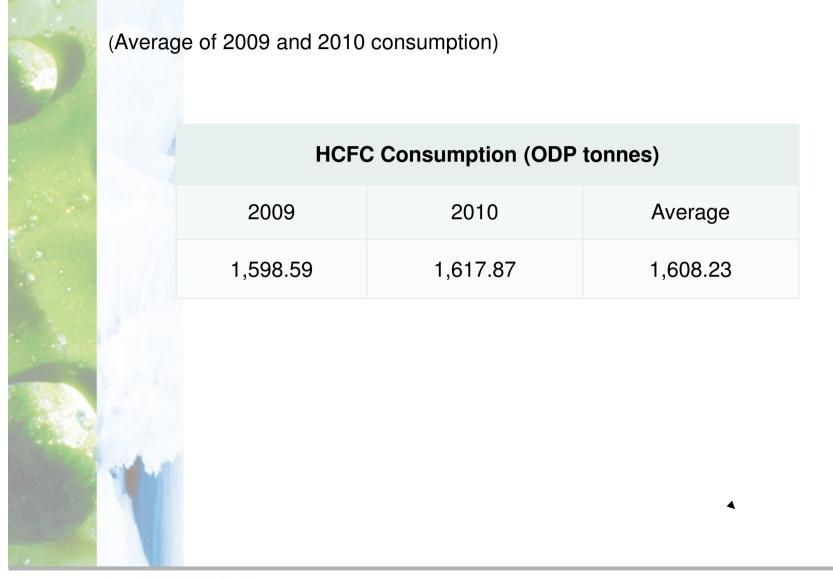


HCFC Phase-out Schedule for Article 5 Parties

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INDIA – HCFC BASELINE





INDIA 2009 HCFC CONSUMPTION (by Sector and Substance)

Sector	HCFC Consumption (metric tonnes)					
	HCFC-22	HCFC-141b	Other	Total		
Manufacturing						
Air Conditioning.	4,944	-	140	5,084		
Refrigeration	340	750	107	1,197		
PU Foams	-	7,979	150	8,129		
Other	180	340	436	956		
Sub-total	5,464	9,069	833	15,366		
Servicing	3,922	-	1,088	5,010		
Grand total	9,386	9,069	1,921	20,376		



Ozone Depletion Impact of HCFCs consumption in India

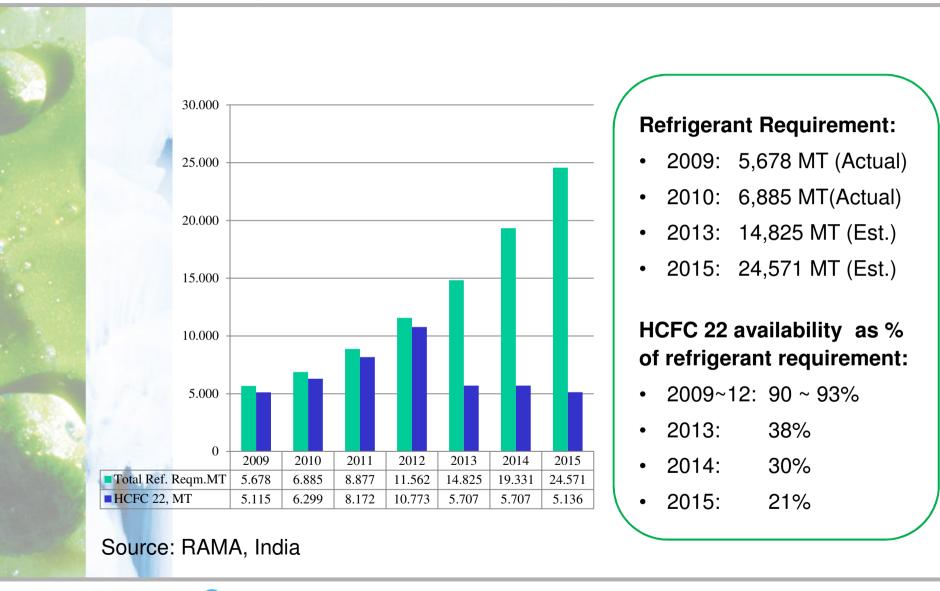
	Substance/ Impact	HCFC- 123	HCFC- 141b	HCFC-22
	ODP	0.015	0.11	0.05
	Consumption in 2010 (metric tonnes)	27	3,983	12,818
	Impact in 2010 (ODP tonnes)	0.41	438.13	640.90
	Projected Consumption in 2015 (metric tonnes)	44	6,416	20,643
4	Impact in 2015 (ODP tonnes)	0.66	705.76	1032.15



Global Warming Impact of HCFCs Consumption in India

Substance/ Impact	HCFC- 123	HCFC- 141b	HCFC-22
GWP	76	720	1,780
Consumption in 2010 (metric tonnes)	27	3,983	12,818
Impact in 2010 (tonnes per tonne CO2)	2,052	28,67,760	22,816,040
Projected Consumption in 2015 (metric tonnes)	44	6,416	20643
Impact in 2015 (tonnes per tonne CO2)	3,344	4,619,520	36,744,540





Refrigerant Requirement & HCFC Availability

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Roadmap for Phase-out of HCFCs in India

- - Meeting of Stakeholders Industry, institutions, GOs, NGOs and implementing agencies
 - Programme Launched

September 2009

October 2009

- The HPMP Stage-I
 - The phase-out of certain HCFCs to meet the 2013 freeze and 10% reduction in 2015
 - Approved in April, 2012 in Montreal, Canada



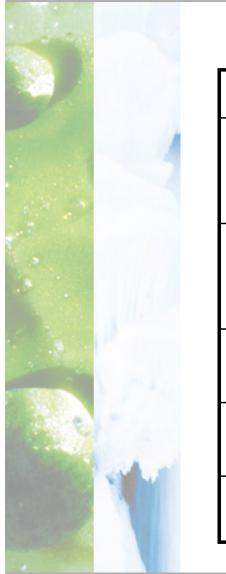
Action Plan HCFC Phase-out



Activity	Agency
Policy and Regulatory Measures	Ozone Cell, MOEF
Awareness for Accelerated Phase-out of HCFCs	UNDP and UNEP under guidance of OC
Data Collection and its Analysis	UNDP with OC, MOEF
Assessment of Alternative Tech. and Tech. Transfer	UNDP, UNIDO, GIZ (Industry and Experts)
Sector Specific Phase-out Strategies	UNDP with other agencies



Action Plan HCFC Phase-out



Activity	Agency
Enterprise wise Project Preparation and Implementation	UNDP, UNIDO, World Bank, GIZ
Sector Plan – Servicing Sector	UNDP and Sector wise Implementing Agencies
Sector Plan – Ref. and Foam Manufacturing	UNDP, UNEP and UNDI
Sector Plan – Servicing Sector	GIZ with UNEP and UNDP
Sector Plan HCFC Production	The World Bank with UNDP and UNEP



Phase-Out Strategy

- Principles
 - Reflect national context and priorities, national policies and countrydrivenness
 - Develop strengthened and proactive partnership between government and industry
 - Draw upon lessons learnt from CFC phase-out from functioning institutional arrangements and operational mechanisms and adapt, strengthen and modify them as necessary
 - Be dynamic and flexible, to respond to evolving needs and situations



Phase-Out Strategy (CONT`D)

- Approach for Stage-I compliance
 - Prioritize manufacturing sectors/sub-sectors where cost-effective, low-GWP alternatives can be adopted
 - Prioritize large, organized and financially sound enterprises in manufacturing
 - Prioritize higher ODP HCFCs, i.e., HCFC-141b
 - Capacity-building and awareness activities
 - Promote recovery and reclamation of HCFC-22 and best practices in the servicing sector
 - Clear, enforceable and targeted regulations that ensure level playing field for industry



Phase-Out Targets (For compliance with Stage-I, 2013 and 2015)

- India's Baseline Consumption for HCFCs is 1,608.23 ODP tonnes. For compliance with Stage-I controls, national HCFC consumption needs to be limited to 1,608.23 ODP tonnes (2013 and 2014) and 1,447.41 ODP tonnes (From 2015 onwards).
- To account for growth in consumption during 2011 and 2012, India would need to phase-out at least 320 ODP tonnes, to comply with the 2013 and 2015 control targets



HPMP STAGE-I IMPACTS

Ozone Layer Protection

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- About 320 ODP tonnes of HCFCs will be phased out leading to sustained reductions of 160.82 ODP tonnes in India's national HCFC consumption from 01 January 2015.
- Global Warming
 - Direct emission reductions of about 4.5 million CO2-eq tonnes annually, due to the GWP of HCFCs phased out.



Natural Refrigerant Options

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CO (R-
Wa (R-
Air (R-

Substance	Applications	Remark
HCs (HC-290, HC- 600a, HC-1270)	Small Capacity Domestic and commercial equipments	Flammability issue
Ammonia (R-717)	Industrial refrigeration and process chillers, Cascade system	Flammability and Toxicity issue
CO2 (R-744)	Supermarket refrigeration in secondary loop and stationary and mobile Acs, Cascade system	Major redesign
Water (R-718)	Steam jet refrigeration and absorption systems	
Air (R-729)	MACs	



Туре	Refrigerant	GWP	Flammability	Toxicity	Normal boiling point	Critical temperature	Potential Efficiency (rel. to R-22)	System cost (rel. to R-22)
HCFC	R-22 *	1810	None	Low	-41°C	96°C	100%	100%
	R-407C	1770	None	Low	-44/-37°C	86°C	75 – 90%	100 - 110%
HFC	R-404A	3920	None	Low	-44°C	72°C	85 – 100%	100 - 105%
	R-410A	2140	None	Low	-52°C	71°C	90 - 105%	100 - 110%
	R-417A	2350	None	Low	-38/-33°C	87°C	90 – 105%	100 - 105%
HFC-based "drop-in"	R-427A	2140	None	Low	-43/-36°C	85°C	85 - 105%	100 - 105%
	R-434A	3280	None	Low	-45/-42°C	76°C	90 – 105%	100 - 105%
	R-717 (ammonia)	0	Low	High	-33°C	132°C	100 - 125%	110 - 140%
Natural refrigerant	R-744 (carbon dioxide)	1	None	Low	-78°C	31°C	85 – 110%	100 - 130%
	R-290 (propane)	< 3	High	Low	-42°C	97°C	95 – 115%	100 - 115%
	R-290/R-600a mix	< 3	High	Low	~ -30°C	~ 115°C	90 – 105%	100 - 110%
	R-1270 (propene)	< 3	High	Low	-48°C	91°C	95 - 120%	100 - 115%

Characteristics of HCFC-22, HFCs and Natural Refrigerants



Hydrocarbons

- Zero Ozone Depletion Potential
- Near zero Global Warming Potential
- Better Energy Efficiency than HCFCs and HFCs
- Compatible with Mineral Oils
- Flammable (Safety aspects required)
- Domestic Refrigeration
- Commercial Refrigeration
- Transport Refrigeration
- Cold Storage & Food Processing
- Industrial Refrigeration
- Air-Conditioning

(HC-290/HC-600a or HC-600a) (HC-290/HC-600a or HC-600a) (HC-290/HC-600a or HC-290) (HC-290) (HC-600a) (HC-290/HC-600a or HC-290)



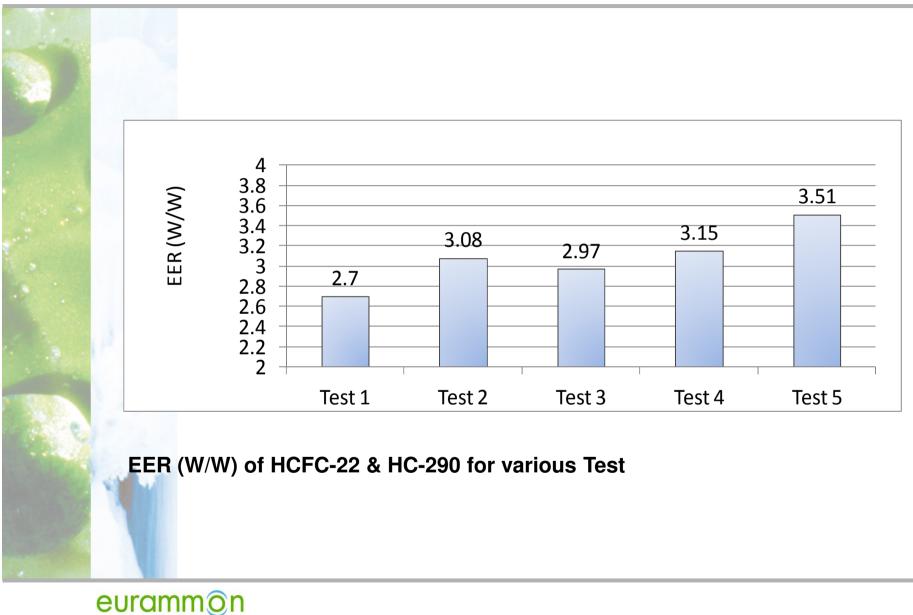
HC-290 :Flammability

	Property	Quantity
	By volume in air (%)	2.1
LFL	By mass (kg/m3 of air)	0.038
	By volume in air (%)	9.5
HFL	By mass (kg/m3 of air)	0.177
Auto ignition te	mperature (oC)	470

Consideration on the use of 2L refrigerants classified by ASHRAE 34 and ISO 817

Class 1 (No flame propagation)	Class 2L (Lower flammable with low burning velocity)	Class 2 (Lower flammable with high burning velocity)	Class 3 (Higher flammability)
CO2(R744) R410A R22	HFO 1234yf R32 Ammonia (Toxic)	R152a	Propane (R290)





Test Results: HCFC-22 and HC-290

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Current Developments on Natural Refrigerants : India

HC-290 ACs (split and Window Units)

Industry	Cooling capacity
Godrej and Boyce Ltd., India	1.5 TR, 1.0 TR

- EER of 3.7, both the 3,375W and the 4,900W cooling capacity models achieve a 5 star rating performance
- Emerson Climate Technologies (India) has indigenously developed a HC 290 compressor
- Godrej sold 3000 SACs with HC-290

Current Developments of Natural Refrigerants in Different Countries

HC-290 Acs

Industry	Cooling capacity
Gree, China	1.0 TR
Benson Airconditioner, Australia	8.0 TR
De Longhi, Italy	1.0 TR

- HC-1270 Chillers
- 1175 kW are used in a fruit storage in UK
- R433b blend of R290 (95%) and R1270 (5%) Prototype Test
- Its ODP value is 0 and GWP value is 3.
- Compared with R22, the system can reduce energy consumption by 28%-30%.



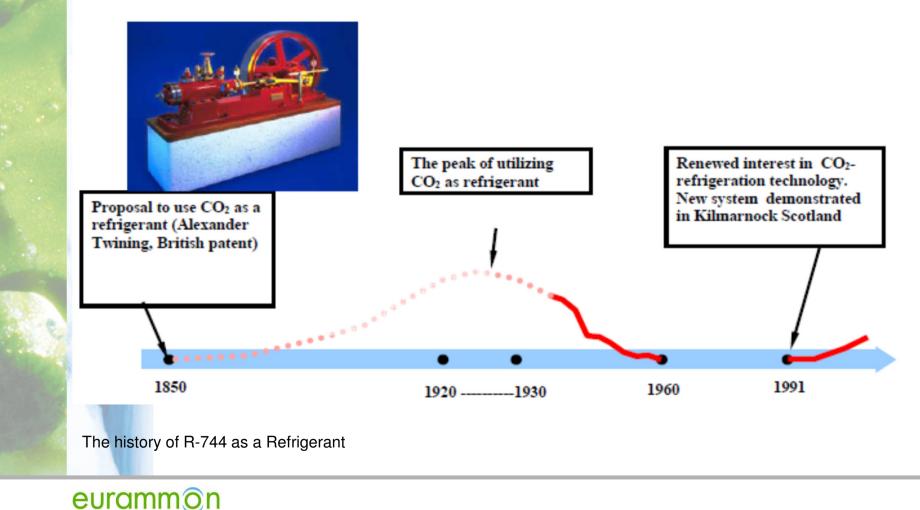
Carbon Dioxide

- Most promising refrigerant having zero ODP and near zero GWP
- Critical temperature is very low
- Cycle is trans-critical
- Operating pressure much higher than other refrigerants
- Higher volumetric capacity
- Non flammable, non toxic and cheap
- Compatible with normal oils
- Excellent performance when used for water heap pump utilizing
- the temperature glide in gas cooler



R-744 (CO2) As a Refrigerant

R-744 has been used in refrigeration for many years.



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CO2 System



Supermarket Pack Installed at ISO Roskilde Denmark This may be expensive to install in the India



Carbon Dioxide

Industry	Year	Unit
ECOCute, Denso Company in Japan	2001	Heat pump used for heating and hot water production with supercritical operation with CO2 10° C to 90° C hot water
Sweden and the Swedish Energy Agency	2007	supermarkets with carbon dioxide refrigeration operating in supercritical systems
Factory-built CO2 systems, Norway	2007	supermarkets with carbon dioxide





Thank You !

