Thoughtful Cooling

Active HVAC Systems

Efficient HVAC systems using natural refrigerants

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Framing the Issue

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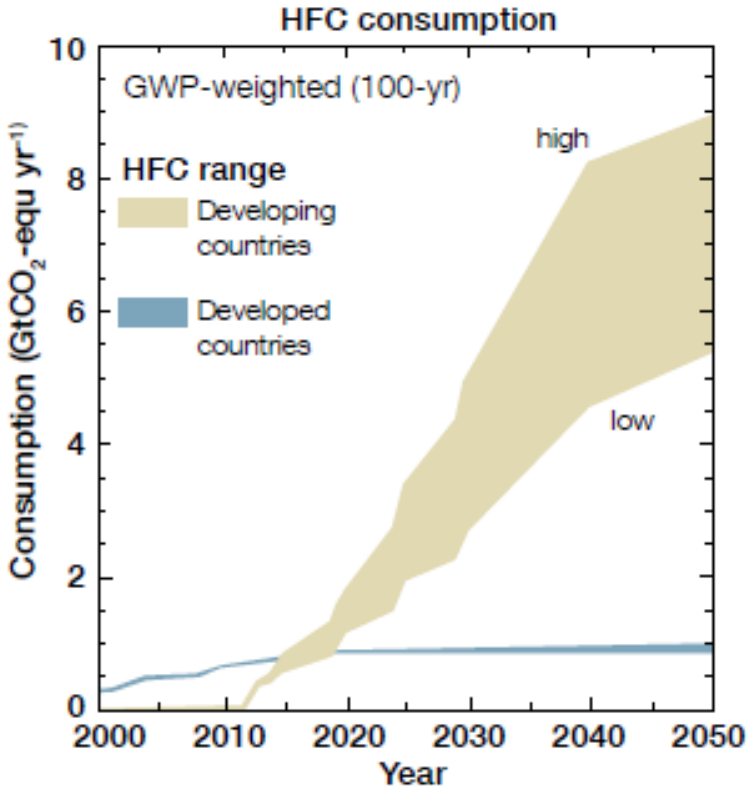
Increased HFC Consumption

Fig 3: Growing HFC market

This graph shows that the rapid growth in HFC consumption will come almost exclusively in developing countries. This is why it is crucial that developing countries leapfrog HFCs straight to environmentally safer technologies.



SOURCE: Velders et al, 2009

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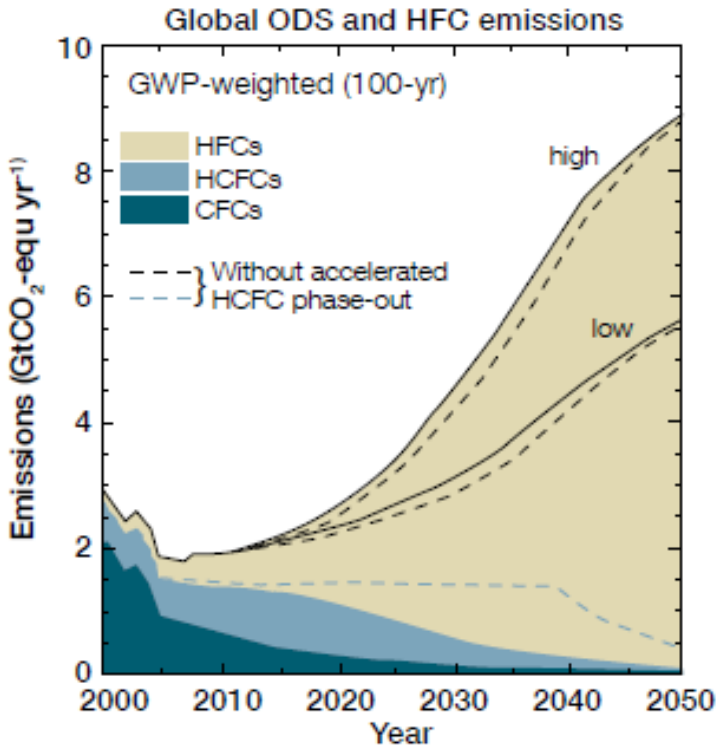
Increased GHG Emissions

Refrigerants	Type	GWP (100 Year, AR 2007)
R410A – R32/R125 – 50:50	HFC	2088
R22 – Chloro Difloro Methane	HCFC	1810
R134A – Chloro Difloro Methane	HFC	1430
R32 – Methylene Fluoride	HFC	675
R290 – Propane	HC, 'Natural'	3.3[16]
R1270 – Propylene	HC, 'Natural'	1.8[16]
R744 – Carbon Dioxide	'Natural'	1
R717 – Ammonia	'Natural'	0

Increased Refrigerant Emissions

Fig 1: Growing HFC emissions

This graph shows that while CFC and HCFC emissions go down (the light-blue blocks), HFC emissions (the light-brown block) will overtake them by around 2025, and rapidly increase up towards 2050.



SOURCE: Velders et al, 2009

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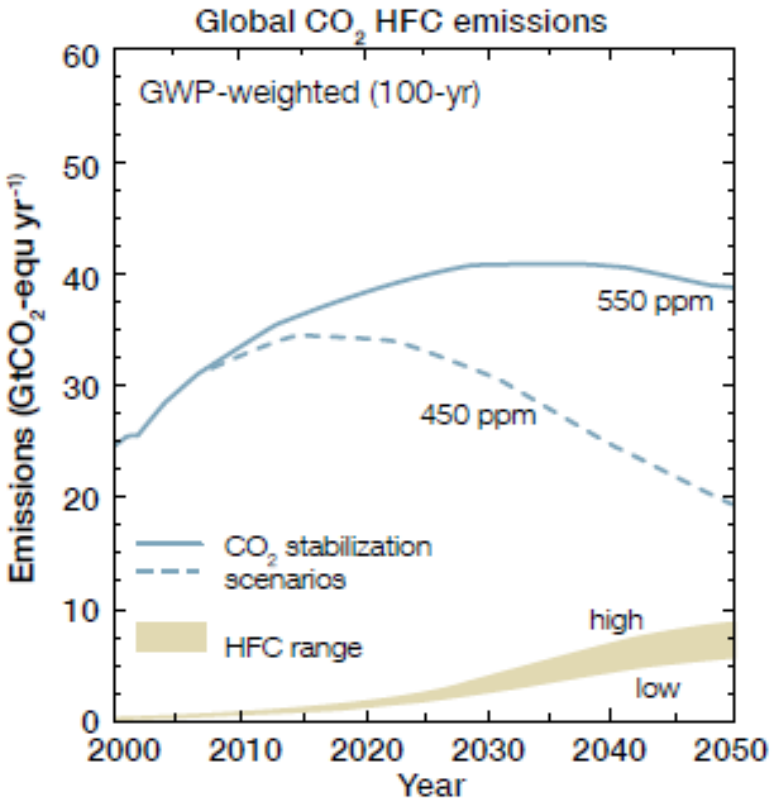
Increased GHG Emissions

Fig 2: HFC vs. CO_2 emissions

This graph compares CO_2 and HFC emissions up to 2050. The line that is most important is the one representing CO_2 emissions if they are kept below 450 ppm - the 2°C threshold. If you compare that with HFC emissions in 2050, then HFCs are responsible for between 28% and 45% of carbon emissions.



SOURCE: Velders et al, 2009

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Increased GHG Emissions

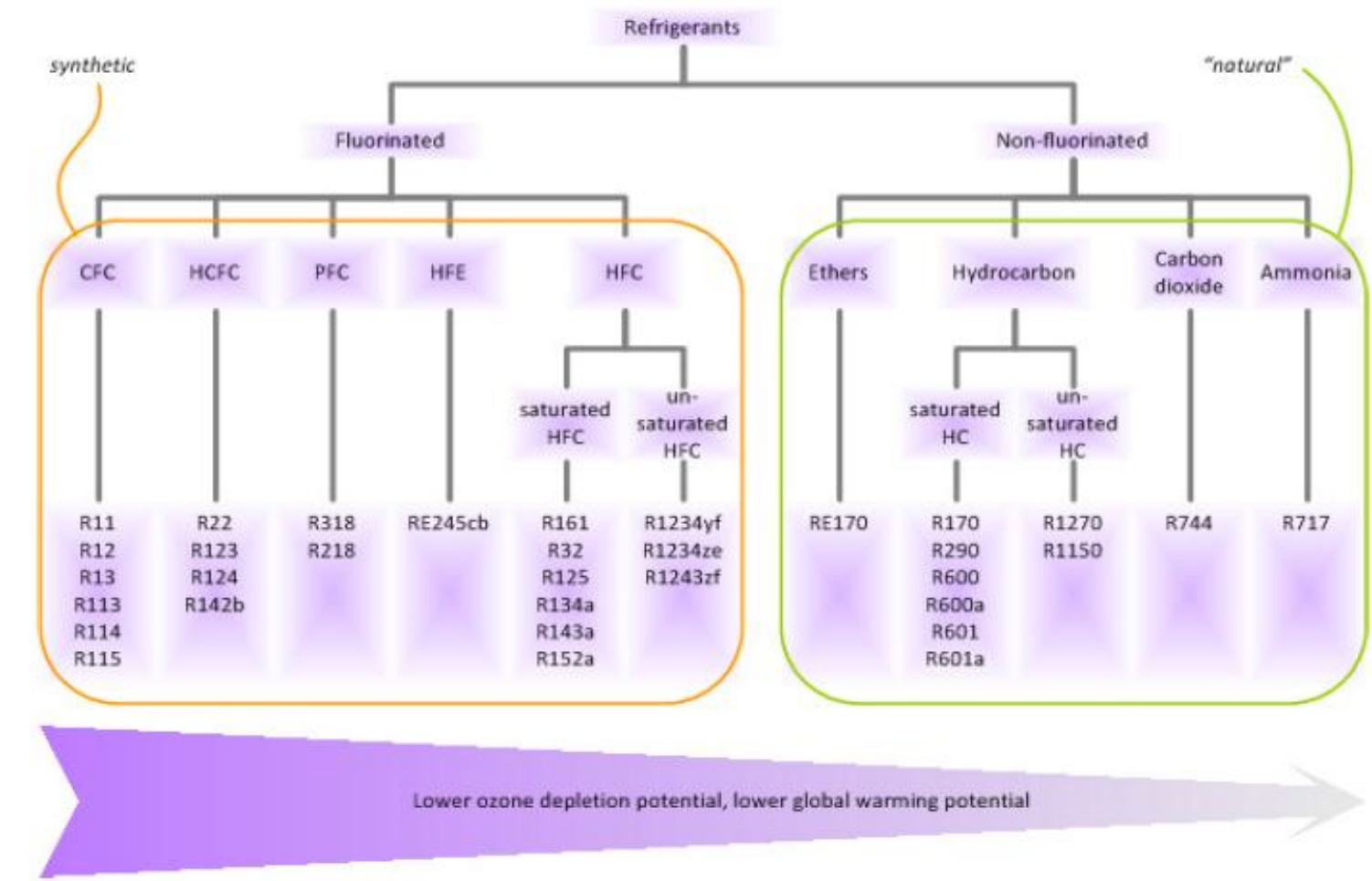
– in fact, **since the implementation of the UNFCCC's Kyoto Protocol, HFC emissions have risen by 15% a year.**[3]

HFCs don't deplete the ozone layer like their predecessors, but they are very powerful greenhouse gases.

If left unchecked, HFCs will counteract other global climate action

The consequences of the rapid growth in HFC emissions are shocking - a recent peer-reviewed report by top scientists shows that if we only focus on reducing CO_2 and do nothing about HFCs, they will be responsible for between **28% and 45%** of carbon-equivalent emissions by 2050. Even if we don't act on CO_2, HFCs would still be responsible for between **10% and 20%** of carbon-equivalent emissions by 2050.

SYNTHETIC AND NATURAL REFRIGERANTS FOR AC



Source: Hydrocarbon Refrigerants For Room Air Conditioners, Daniel Colbourne, for GIZ Proklima, March 2011

Comparison of Conventional and Natural Refrigerants

Refrigerants		ODP	GWP	Flammability	Refrigerant Characteristics
Current Refrigerants in Energing countries	HCFC22	0.055	1810	Non-flammable	Production to be completely phased out in developed countries by 2020
Current Refrigerants in Developed countries	HFC410A	0	2,088	Non-flammable	Slowly replaced by propane in developed countries
Next generation Refrigerants	HFO1234yf/ze	0	4-6	Slightly flammable	No impact on ozone and low GWP.Safety and Price issue
	HFC32	0	675	Slightly flammable	No impact on ozone and one of the lowest GWP among HFCs. Flammable
	CO_2	0	1	Non-flammable	No impact on ozone and low GWP. Low efficiency when used for AC
	Propane (R290)	0	3	Highly Flammable	No impact on ozone and low GWP. An efficient refrigerant, but highly flammable and susceptible to explosion

Natural Refrigerants ACs

What are Natural Refrigerants?

- Chemicals which occur in **nature's bio-chemical** processes
- Can be used as cooling agents in refrigerators and air conditioners.
- Do not deplete the ozone layer and make negligible contribution to global warming.
- **High efficiency** = lower indirect contribution to global warming than many FC's

Why use Natural Refrigerants?

- Natural refrigerants deliver on the Montreal and Kyoto Protocols.
- Natural refrigerants have no or very low Global Warming Potential (GWP)
- Zero Ozone Depleting Potential (ODP) – **Montreal Protocol**
- Reduction of CO_2-equivalent emissions – **Kyoto Protocol**

Types

- Natural Refrigerants can be divided into :
  - Hydrocarbons – Propane (R290), Propylene (R1270), R600a
  - Ammonia
  - Carbondioxide

Applications and Limitations

- Ammonia
  - Application: Large air conditioning systems (chillers), commercial & industrial refrigeration (storage, food, brewing, heat extraction, ice rinks etc.)
  - Limitation: Ideal & efficient refrigerant if used in accordance with national safety standards and codes of practice.

- Carbon Dioxide
  - Application: Static/mobile air conditioning systems, warehousing, commercial refrigeration, chill cabinets and vending machines, process chilling, low- and ultra-low-temperature applications.
  - Limitation: Often used as a secondary refrigerant along with ammonia, thereby opening up applications where ammonia as a single-stage refrigerant would not be applicable

- Hydrocarbon Refrigerants
  - Applications- Industrial and domestic air conditioning, domestic appliances, commercial and industrial refrigeration, chill cabinets and vending machines, heat pumps, low- and ultra-low temperature applications
  - Limitation- Extremely inflammable

Benefits

- **Regulatory Compliance** – In many countries, the use and availability of HCFCs and HFCs are controlled by legislation due to their environmental impact.
  - Not subject to the Montreal Protocol, Kyoto Protocol or other related local environmental legislation.

- **Low environment impact** – They have zero ODP and minimal GWP. In comparison, commonly used HCFCs and HFCs have a GWP varying from hundered to thousands.

- **High Performance**- They have excellent thermodynamic properties.

- **Cost competitiveness**- Use of natural refrigerants generally leads to lower operating costs due to less leakage, lower maintenance requirements and better energy efficiency.

- **Compatibility** – Natural refrigerants work well with commonly used oil and fluids.

AC Refrigerants Analysis

THE PRINCIPAL CRITERIA FOR REFRIGERANT GAS

Different refrigerant options of ACs are compared with each other on three main characteristics which are

- **Environmental**
- **Safety**
- **Efficiency**
- **Price**

AC Refrigerants Analysis

Refrigerant Safety / Toxicity Classification

Classification			Toxicity	
			Class A	Class B
			lower chronic toxicity	higher chronic toxicity
Flammability	Class 1	no flame propagation	A1	B1
	Class 2	lower flammability	A2	B2
	Class 3	higher flammability	A3	B3

AC Refrigerants Analysis

Environmental Perspective: Natural Refrigerants (Green Coloured) Are Best

Refrigerants	Atmospheric Life (Years)	Ozone Depletion Potential	Global Warming Potential (100 Year Integration)
R22 – Chloro Difloro Methane	11.9	0.034	1700
R410A – R32/R125 – 50:50		0	2000
R32 – Methylene Fluoride	5	0	550
R290 – Propane		0	3.3[16]
R1270 – Propylene		0	1.8[16]
R744 – Carbon Dioxide	>50	0	1
R717 – Ammonia		0	0

AC Refrigerants Analysis

There is no Ideal Refrigerant Gas but Natural Refrigerant are Globally Preferable

- R22 a HCFC Refrigerant which is in Phasing out Condition is used for Comparison and It depletes ozone and has high Global Warming Potential
- R32 and R410A – HFC Refrigerants are having high Global Warming Potential of 2000 and 550 respectively and has Safety Factor of A2 and A1.
- R290 and R1270 – HC Refrigerants are not harmful to either Ozone nor Contribute to Global Warming but these are flammable Refrigerants having safety factor A3
- R717 – Ammonia Refrigerant is an environmental friendly gas but it is a toxic gas and flammable gas having safety factor B2
- R744 – Carbon Dioxide is an environmental friendly and safe gas to use but demands higher operating pressure and expert design.

AC Refrigerants Analysis

Safety Perspective: Natural Refrigerants Need Some Precautions

Refrigerant Type	Safety
HFC R32	Lower Toxicity, Lower Flammability - Safety Factor A2
	Changes to System Construction must be addressed
HFC R410A	Lower Toxicity, Non Flammability - Safety Factor A1
	Changes to System Construction must be addressed
HC R290 and R1270	Lower Toxicity, Higher Flammability - Safety Factor A3
	Changes to System Construction must be addressed and reduce charge size to mitigate flammability Risk
Ammonia R717	Higher Toxicity, Lower Flammability - Safety Factor B2
	Specially for Indirect Systems or Direct Systems in unoccupied spaces (store-rooms), Needs Specialized Design Work
Carbon Dioxide R744	Lower Toxicity, Non Flammability - Safety Factor A1
	Restriction in application, has higher operating pressures so cannot be used in existing systems. Supercritical cycle demands expert design

AC Refrigerants Analysis

Economic (Price) Perspective: Natural Refrigerants Are Inexpensive

- **Universally Available**
- **No Patent**
- **Direct Material cost (Refrigerant Cost) of HC-AC and Conventional ACs are not significant for comparison**
- **Life Cycle Analysis of HC-AC with Conventional AC is presented in slides no. 19 - 28 Slides**

AC Refrigerants Analysis

Efficiency Perspective: Natural Refrigerants Are Energy Efficient

Parameters	R22	R290	R1270	R410A	R32
Volumetric Refrigerating Effect (KJ/m^3)	4359	3716	4643	6275	6824
Relative to R22 (%)	0	-15	2	44	57
Discharge Temperature (Deg C)	95	77	83	92	111
Relative to R22 (Deg C)	0	-18	-13	-3	15
Coefficient of Performance (KW/KW)	4.23	4.28	4.21	3.96	3.98
Relative to R22 (%)	0	1	-1	-6	-6

Efficiency Related Data of R744 (Carbon Dioxide) and R717 (Ammonia) is not available

AC Refrigerants Analysis

Volumetric Refrigerating Capacity : broadly indicative of required compressor displacement. It is seen that R290 has 15% lower capacity than R22, whilst R1270 is almost the same as R22 but it is almost 1.5 times for R32 and R410A.

- It implies that the R290 compressor demands a larger geometric swept volume in order to achieve the same cooling capacity and R32 and R410A Requires lower Geometrical Swept Volume.
- However, despite the cycle calculations implying this, most practical studies have found that the refrigerating capacity of R290 in a fixed displacement compressor is much closer to R22 – typically within 5% to 10% – which is due to R290 having a higher volumetric efficiency

AC Refrigerants Analysis

Volumetric Refrigerating Capacity (kW / m3) = cooling achieved per unit volume of refrigerant moving through the compressor

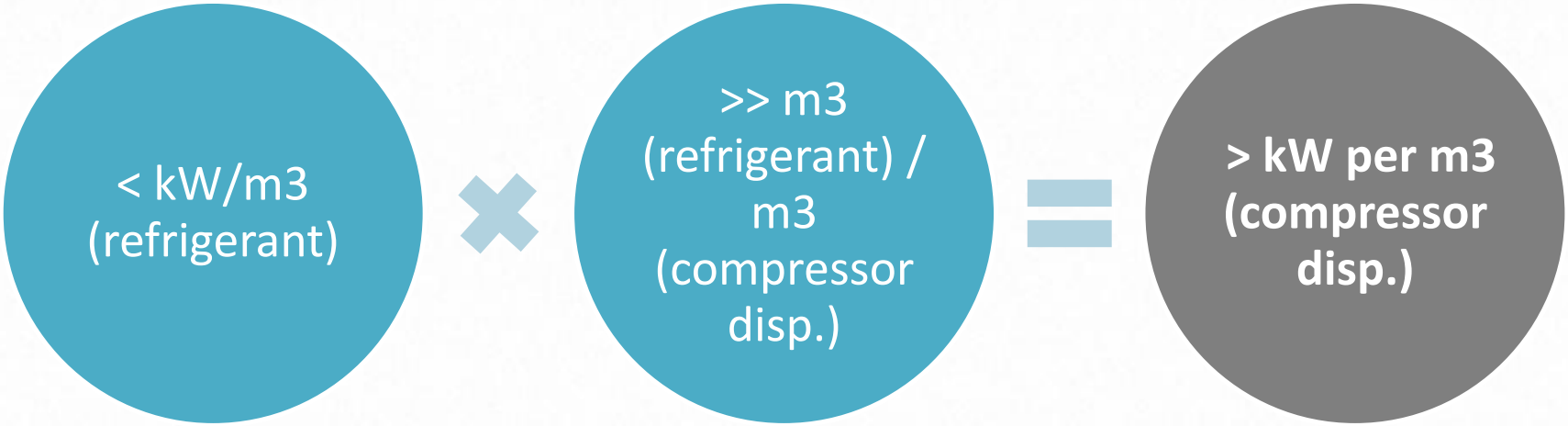
While this is LOWER for R290 vs. say R22, the cumulative effect of kW/m3 and the higher volumetric efficiency needs to be considered to gauge overall efficiency of the refrigerant.

Volumetric Efficiency:

$$\eta_v = \frac{\text{Volumetric flow rate}}{\text{Compressor Displacement rate}} = \frac{\dot{m}.v_e}{\dot{V}_{sw}}$$

where:
m (kg/s) = mass flow rate of refrigerant
V_{sw} (m^3/s) = compressor displacement rate
V_e (m^3/kg) = specific volume of the refrigerant at compressor inlet

AC Refrigerants Analysis



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AC Refrigerants Analysis

Under smaller temperature lifts (i.e., using larger heat exchangers) R290 performance improves even more relative to R410A and R32

Ideal cycle efficiency is virtually the same as R22; however, the thermo-physical properties of R290 (and R1270) are particularly favourable, which provides further benefit in terms of potential performance

Source: HYDROCARBON REFRIGERANTS FOR ROOM AIR CONDITIONERS
Daniel Colbourne, for GIZ Proklima
March 2011

AC Refrigerants Analysis

DISCHARGE TEMPERATURE: is most important especially for hot climates. R290 has a discharge temperature some 20 Deg K less, R1270 about 15 Deg K less, R410A is 3 Deg K less but R32 is 15 Deg K Greater than R22. Therefore R290 potentially offers notable benefits in terms of compressor reliability, especially in hot climates.

THE COEFFICIENT OF PERFORMANCE (COP): R290 and R1270 are the similar or slightly greater than R22 but COP of R32 and R410A is less by 6% when compared with R22.

Basic Safety Concept

CNG as a fuel is flammable,
but would you call a CNG Car 'Flammable'?

LPG as a fuel is flammable,
but would you call your kitchen 'Flammable'?

Safety Considerations for R290

Flammability Concerns Related to R290

NOTE: the following concerns are already addressed in equipment construction practices and all risks associated with Hydrocarbon Refrigerant use are mitigated through compliance with all legal norms and safety regulations

- It belongs to safety group A3 and is highly flammable and non toxic.[4]
- Lower Explosive Limit – 2.1 %, Upper Explosive Limit – 9.5 %. [5]
- Color Less and Odor less Gas
- Flash Point is below the atmospheric temperature and exposure to atmosphere in combination with spark/flame/hot surface may cause fire immediately
- Readily forms an explosive air-vapour mixture at ambient temperatures.
- Vapour is heavier than air and may travel to remote sources of ignition (e.g. along drainage systems, into basements etc).[6]

Safety Considerations for R290

SAFETY CONSIDERATIONS FOR USING R290 REFRIGERANT IN ACs BY CATEGORY 'A' PEOPLE

Here we are addressing safety considerations of ACs with special reference R290 refrigerant for its use in commercial/residential ACs. All general safety considerations like electrical operations, Installation site etc has to be followed as followed during HCFC/HFC ACs installation / Repair / Modification / maintenance / disposal

Safety can be addressed by using 5 broad classifications:

A. **During Construction / Manufacturing**

B. **During Operation**

C. **During Maintenance / Recharging**

D. **During Disposal**

E. **Additional Safety Considerations**

Safety Considerations for R290

SAFETY CONSIDERATIONS DURING CONSTRUCTION / MANUFACTURING

- All tubing joints should be brazed properly, should not be installed in such a way that bends or joints are stressed and should be cross checked. [7]
- Since R290 is denser than air, it will collect at the bottom of the enclosure in case of leakage therefore the base is constructed as a leak-proof pan so that any releases will be held within the enclosure. [8]
- At least one gas sensor is positioned inside air tight enclosure, where upon exceeding a pre-set concentration the gas sensor isolates the electricity supply and also give a warning signal.
- Even if the total HC-290 leaked make sure that the concentration is below the explosive density of R290 (43.6 to 175 g/m3). [7]
- The electrical components like capacitor, thermostat switch has to be sealed. [7]
- No valves and detachable joints must be located in areas accessible to the general public. Ensured that the refrigerant charge of the of the system do not exceed the charge size limits. [8]
- All refrigerant-containing and other critical parts of the equipment must be protected from mechanical damage.

Safety Considerations for R290

SAFETY CONSIDERATIONS DURING CONSTRUCTION / MANUFACTURING

- Equipment housing should be designed and constructed to be robust resistant to weathering and other forms of damage
- Insulate all tube connections professionally to avoid formation of water condensation and water damage to the rooms.
- Labeling of the system with the type and quantity of refrigerant inside. [8]
- When designing pipe work and selecting components, it is preferable to have as few pipe joints and seals.
- Ensure that all the materials that are to be used within the refrigeration system (particularly valve seals, o-rings, etc), are fully compatible with the HC refrigerant to be used. It is important to be aware that the compatibility of refrigerants. [8]
- Where vibration eliminators or flexible connectors are required, they must be installed ensure that they do not cause catastrophic leakage.
- Storage and Handling of Product and parts has to be done by taking utmost care

Safety Considerations for R290

SAFETY CONSIDERATIONS DURING OPERATION

- Smoking has to be prohibited. [6]
- The equipment should be positioned so that there is always good free ventilation around all sides of the equipment, and it will not be inhibited by any permanent or temporary blockages.
- The area should be free of combustible materials. [6]
- The equipment housing should be designed to prevent or inhibit interference from others, possibly by Locks etc.
- Consideration should be given to the positioning of the equipment with regards to areas where people may congregate or gather.
- Do not install system in Humid places and do not clean the system with water. [6]
- Air Conditioner must be kept away from fire, spark with energy > 20mJ /hot surfaces > 450 deg C to prevent the ignition of R290 (Auto ignition temp 540 deg C). [8]
- If anything irregular occurs like burnt parts, smell, loud noise then disconnect the system immediately and isolate the system from electric supply. [6]

Safety Considerations for R290

SAFETY CONSIDERATIONS DURING MAINTENANCE & RE-CHARGING

- Regular maintenance and system checks have to be made. [8]
- Any technician working on a system must be properly trained and certified with the appropriate qualifications. [8]
- Before servicing the unit, the surrounding area where the work will be done must be clear of safety hazards to ensure safe working. [6]
- Nevertheless it is required to carry out a risk assessment in order to minimise the risk of ignition of R-290.
- It is recommended to isolate the working environment in order to keep out any unauthorised personnel. [6]
- It is prohibited to store any combustible goods within the working environment.
- Within two (2) metres radius, ignition sources are not allowed in the working area. [6]
- Fire extinguisher (dry powder) must be easily accessible at any time. [6]

Safety Considerations for R290

SAFETY CONSIDERATIONS DURING MAINTENANCE & RE-CHARGING

- Do not charge the system with any refrigerant which is not R290. Do not mix any refrigerant. [6]
- Servicing by competent technicians must be done by using proper equipment.
- Before Recharging the refrigerant technician must do leak testing. [8]
- Before filling ensure that there is no air or other non condensable gases like nitrogen etc left in the system. [6]
- While recharging technician has to ensured that the refrigerant charge of the of the system do not exceed the charge size limits and he must also ensure that the quantity of recharging is not less than specified as it may reduce the system performance. [6]
- After recharge examine and confirm by the use of appropriate leak test. [6]
- Retrofitting has to be done by trained technician

Safety Considerations for R290

SAFETY CONSIDERATIONS DURING REFIRGERANT RECOVERY

- The recovery cylinder must be permitted for the use of R-290 (especially regarding the pressure and the compatibility of the connectors and the valves).
- The recovery machine must be suitable for operation with R-290. Importantly, the recovery machine must not itself be an ignition source.
- The filling of recovery cylinder should be monitored closely by controlling the weights. The cylinder should not be filled more than 80% of its complete volume by liquid refrigerant
- Pressure and mass of the cylinder must be controlled.
- After recovery type of recovered refrigerant must be marked. Recovery machine has to be operated until the pressure reduces to 0.3 bar. R290 is soluble in oil. This may lead to rise in pressure as refrigerant vaporizes from oil.
- It may be necessary to operate the recovery machine for a second or even a third time.

Safety Considerations for R290

SAFETY CONSIDERATIONS DURING REFIRGERANT RECOVERY

- Remaining amounts of HC absorbed by the oil can be extracted from the system using a vacuum pump in combination with an exhaust vent hose.
- Small amounts of R-290 can be vented in safe manner to the environment.
- After the systems‘ pump out, the system should be flushed with Oxygen Free Dry Nitrogen (OFDN) in order to ensure no flammable gas are inside the system.

Safety Considerations for R290

SAFETY CONSIDERATIONS DURING LEAK REPAIR

- Removing the refrigerant from the system in order to avoid an uncontrolled discharge.
- Examine the leak source, determining the reason for the leak and carry out the proper course of action.
- Repair properly (NO “temporary repairing”)
- Based on the results of the systems’ examination, suitable measures need to be identified in order to avoid a recurrent appearance of the leak.
- Before embarking on the repair, ensure that the refrigerant has been removed and the system flushed with OFDN, especially if brazing is to take place.
- After each intervention into a refrigeration system (repairing leaks, replacing components, brazing) the system must be subject to a leak test and following strength test of the system.

Safety Considerations for R290

SAFETY CONSIDERATIONS DURING DISPOSAL

- Recovering of the refrigerant must be done by trained technician.
- During recovery ensure that there is no Spark / Flame / Hot Surface around the system.
- Recovery of the refrigerant must be done at the end of the system life. [8]
- Recovery must be done in ventilated environment. If at all leak occurs the concentration of R290 gets reduced.

Safety Considerations for R290

OTHER SAFETY CONSIDERATIONS

- R290 is a Class 1 type of flammable material must be enclosed in strong enclosure. [9]
- Enclosure should be strong enough to sustain internal explosion.
- The walls must be thick enough to withstand internal strain during explosion. [9]
- The equipment must provide a way for burning gases to escape.
  a. Only after the gases have been cooled off and their flames are quenched. [9]
  b. This will avoid the damage to the external surrounding. [9]
- The escape route for gases is provided through several flame paths of very less tolerance. [9]
- Importance to protect flame paths during installation, handling, maintenance, shipping etc. Even a slight damage to the flame paths can permit gases to escape and ignite the surrounding atmosphere. [9]

Safety Considerations for R290

KEY SAFETY CRITERIA – AC CIRCUIT CHARGE LEVEL

EN 378 : 2007 and DIS ISO 5149 : 2007

For Systems That Contain Charge Size more than 150 g

Typically HC achieve "A3" classification. The maximum charge for any refrigerant depends on the occupancy category and on the location of the refrigerant-containing parts.

For Category A type of occupancy - general occupancy not restricted at all. Dwellings and public places maximum charge limits are as below

Category A : General Occupancy, Dwelling and Public Places		
Sl/No	Particulars	Maximum Charge Size
1	System in Human occupied spaces	1.5 Kg If System is placed above the Ground level
2	System in mechanically ventilated enclosure	130 * LFL of the Refrigerant
3	System in Open Area	5.0 Kg If System is placed above the Ground level

Allowable charge quantities are calculated based on the formula giving due considerations to area of the room and height at which ACs are placed

$A_{Rm} = (M_{AL} / 2.5 * (LEL)^{(1.25)} * h)^2$

A_{Rm} = Room Area

M_{Al} = Allowable Mass per Circuit

LEL = Lower Explosive Limit (Kg/m3) for R290 is 0.038 Kg/m3

h = Height in (m), according to position of the equipment

- h = 0.6 m for floor mounted
- h = 1m for window mounted
- h = 1.8 m for wall mounted
- h = 2.2 m for ceiling mounted

Safety Considerations for R290

KEY SAFETY CRITERIA – COMPLIANCE by GODREJ EON AC

B. TECHNICAL FEATURES & SPECIFICATIONS FOR SAFETY

- Additional protection sleeves are provided on the wire - to disable the chances of accidental combustion
- Limitation of installation pipe length up to 6m only - to ensure refrigeration charge does not exceed mass required to mitigate chances of accidental combustion
- GMCC PH310G2C-4KTH compressor
- Internal OLP (Overload Protection) for compressor and burst-proof capacitor

C. CONSIDERATION OF INTERNATIONAL STANDARDS FOR SAFETY:-

- European standard (EN 378), limitation is 360~365gm for a 1.5T SAC – HCACs are within this limit

D. TECHNICAL EXPERT SUPPORT:

- Service capabilities across India
- Installation and post installation support for the products

E. PROVED ENERGY SAVINGS:

- HCAC achieve the Energy Savings primarily because of lower working pressure than R22
- Godrej can share PH for specific customers as the need arises - unable to share the PH at present due to design confidentiality

Basic Safety Concept

CNG as a fuel is flammable,
but would you call a CNG Car 'Flammable'?

LPG as a fuel is flammable,
but would you call your kitchen 'Flammable'?

11. EXAMPLES OF R290 ACs MANUFACTURES AND USED IN INDIA AND OTHER PARTS OF WORLD

Country	Company	Equipment Details
India	Godrej & Boyce	In 2012, Inaugurated a new production line for the manufacturing of split and window type propane (R290) air conditioners. The new line is in the 1.5 T split A/C category, which is the most common air conditioner segment in India.
		R290 models do consume 23% less energy than the current top of line 5 star models across other brands.
Denmark	Bundgaard Køleteknik	Producer of hydrocarbon chillers in the medium to larger range 50-400 KW
		HC Chillers are 10% energy efficient than HFC Chillers

11. EXAMPLES OF R290 ACs MANUFACTURES AND USED IN INDIA AND OTHER PARTS OF WORLD

Country	Company	Equipment Details
Moved from Italy to china with a JV with TCL	TCL DeLonghi Home Appliances	De'Longhi had been producing a wide range of portable air conditioners for varying room size using hydrocarbon as refrigerant in the European market since 1995.
		De'Longhi had products in its basket from wall mounted A/c to Split A/c's using R290 as refrigerant and its capacities varying from 8000 BTU/hr to 11,253 BTU/hr. Now R290 range is very limited
Sweden	Frigadon	Frigadon has developed a range of hydrocarbon packaged air conditioners using R1270 (propylene).
		Frigadon installations can be found in the United States, Germany, United Kingdom and Ireland, with companies such as Sainsbury's, COOP Bank, British Land, Coopllands Bakery, Nestle, Dunnes Stores, Braehead Foods, BP, Roche Pharmaceuticals and Welcome Break Motorway Services
Japan	Mayekawa	Developed a central air conditioning and hot water supply system prototype using hydrocarbon zeotropic blend of isobutene and propane. The system uses air and water as the heat source and heat sink to provide cooling, heating, and hot water production. It is yet to be commercialised

11. EXAMPLES OF R290 ACs MANUFACTURES AND USED IN INDIA AND OTHER PARTS OF WORLD

Country	Company	Equipment Details
Australia	Benson Air Conditioning	Markets a variety of Domestic and Commercial HC-AC that are manufactured in China and Thailand
		According to the company, the HC-ACs perform with 15 to 20% better energy efficiency than company's previous R22 range
		Has a vide variety of Product Range whose capacities ranging from 2.31 KW to 17.5 KW with charge size varying from 300 gram to 1.2 Kg and Range varying from Wall mounted Split Systems to Ducted Systems.

11. EXAMPLES OF R290 ACs MANUFACTURES AND USED IN INDIA AND OTHER PARTS OF WORLD

Country	Company	Equipment Details
China	Gree Electric Appliances	Developed propane (R290) domestic split air conditioner with a COP of 3.52 - 3.55 and its energy efficiency is 15% better than corresponding HCFC 22 units.
		In 2011, Gree officially launched its production line for the hydrocarbon air conditioners with a capacity of 100,000 HC AC units per year.
		Gree produces hydrocarbon portable AC and dehumidifiers. The company reports 10% efficiency gains with the portable AC units and 20% efficiency gains with the dehumidifiers.
		Gree AC Capacity Ranges from 9K BTU/hr to 12K BTU/hr with charge size from 265gram to 330gram
		Gree has included safety measures in the system by installing a refrigerant leak alarm system that turns off the compressor, keeps fans operating, and sets off an alarm with flashing lights.

Natural Refrigerant Split ACs

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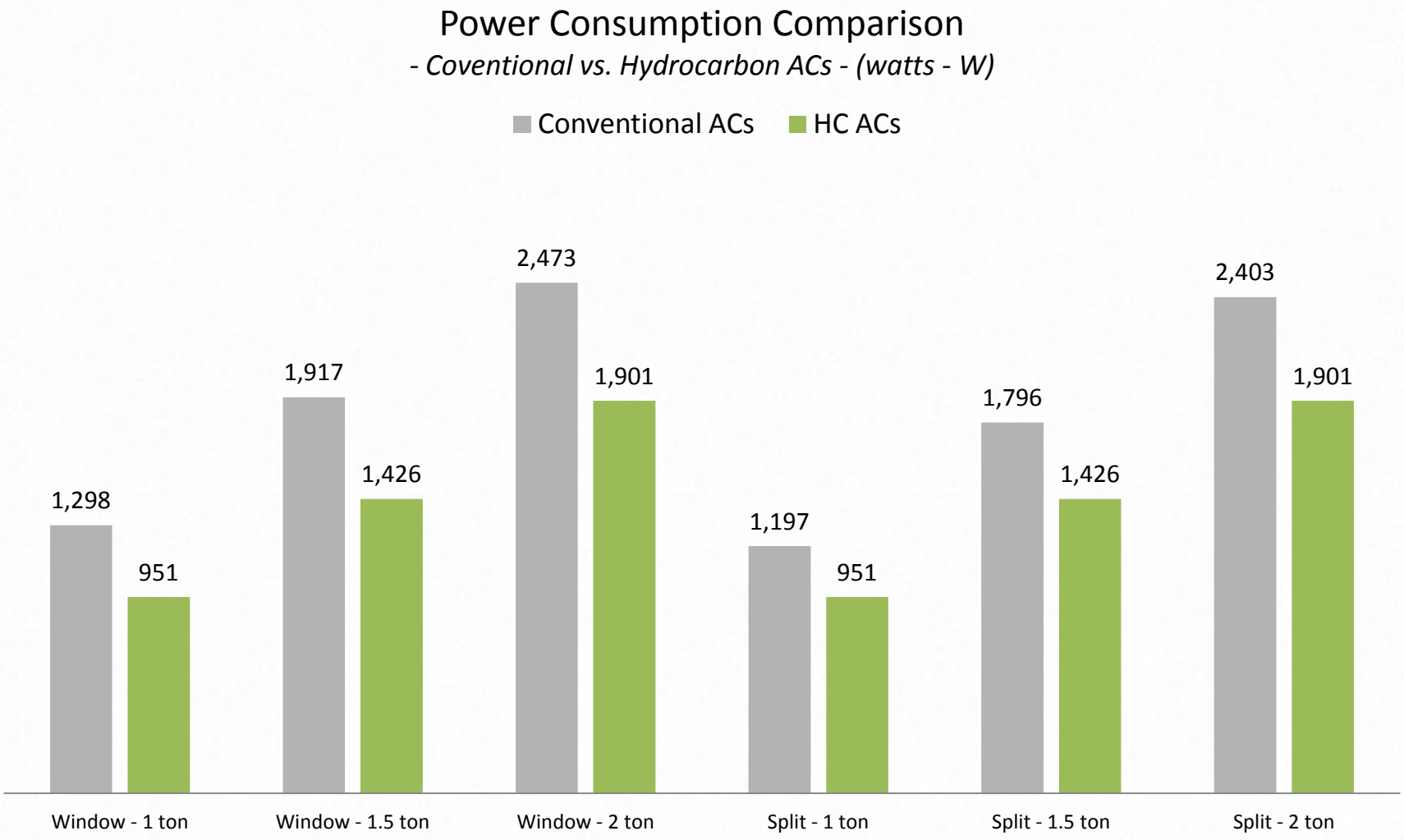
HC-AC vs. Conventional Split/Window ACs

A. EFFICIENCY IMPROVEMENT



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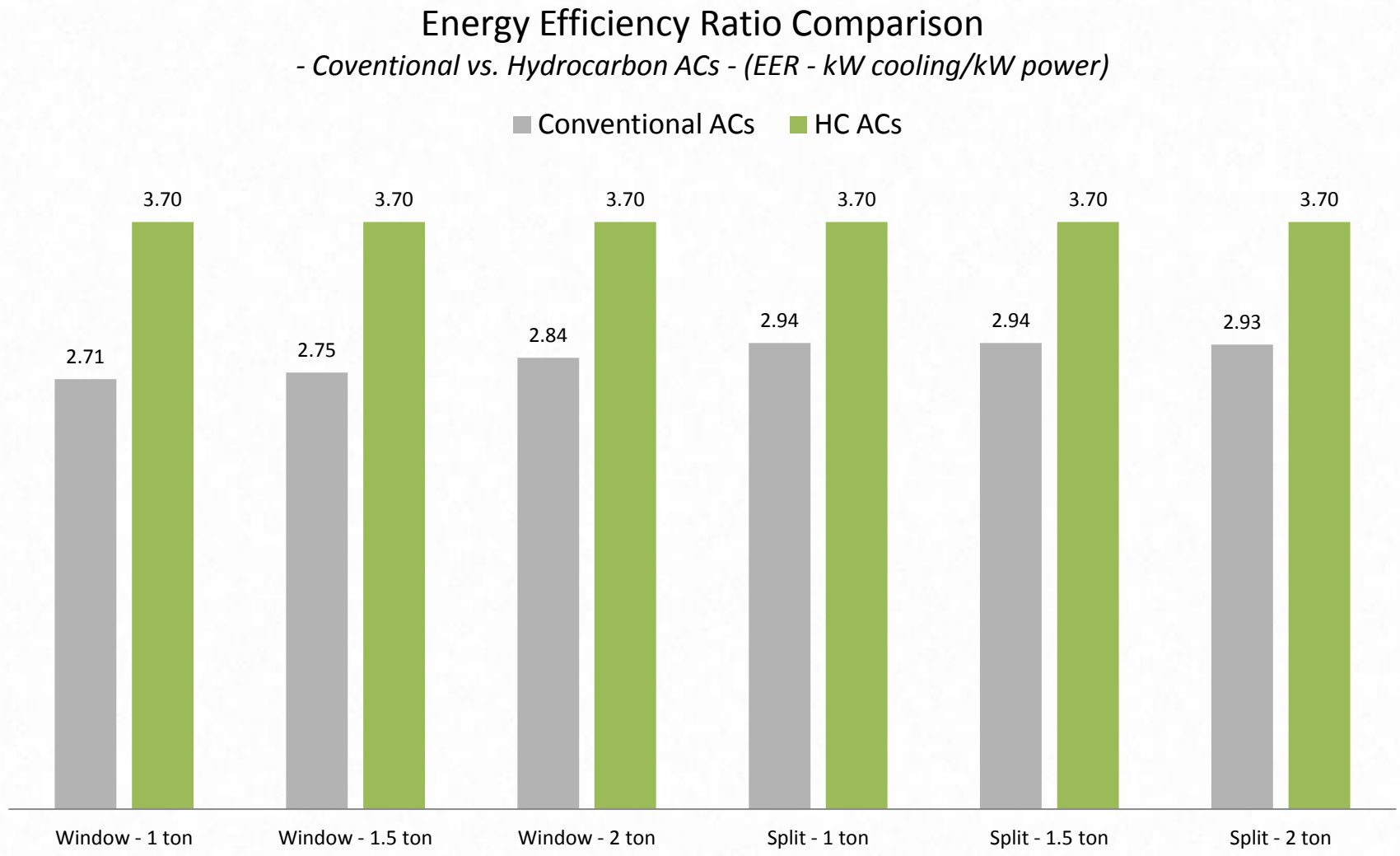
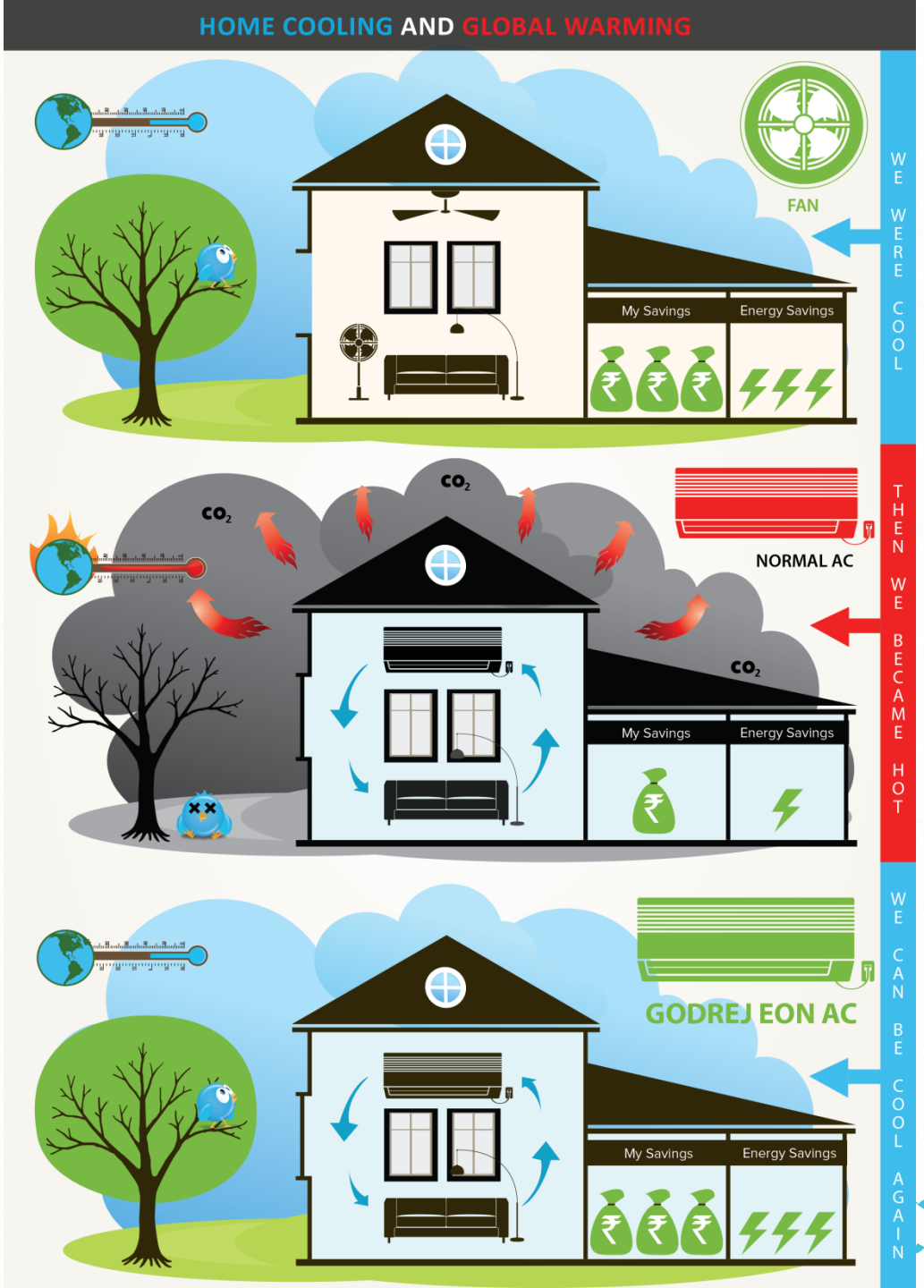
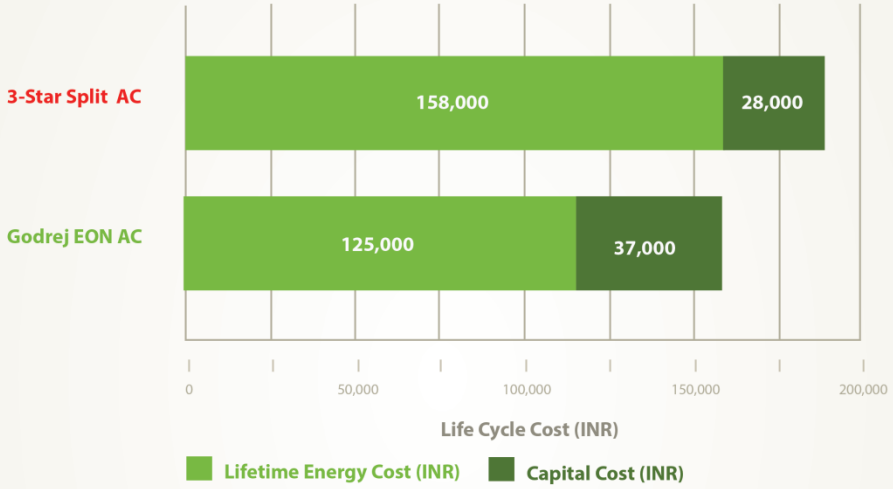



HOME COOLING AND GLOBAL WARMING
FAN
My Savings
Energy Savings
WE WERE COOL
CO_2
CO_2
CO_2
NORMAL AC
My Savings
Energy Savings
THEN WE BECAME HOT
GODREJ EON AC
My Savings
Energy Savings
WE CAN BE COOL AGAIN

CHEATED BY YOUR AC?

While a conventional 3-Star 1.5 ton Split AC costs about Rs. 10,000 less than the 1.5 ton Godrej EON AC, over the 10 year life of the AC, it actually costs more - about Rs. 23,000 more. This is due to the 25% to 30% lower energy consumption of Godrej EON ACs compared to a 3-Star AC.



IF A SINGLE HOME WERE TO USE THE GODREJ EON AC INSTEAD OF A REGULAR 3-STAR AC, IT WOULD RESULT IN THESE POWERFUL BENEFITS FOR ALL – THE HOME AND THE COMMUNITY

- 36 ceiling fans would be cooling less privileged homes
- 120 light bulbs would be lighting up less privileged homes
- Rs 10,000 can be saved annually on electricity bills
- 3 lesser cars would be polluting our environment

This is not an advertisement for Godrej EON AC. It is a objective, scientific assessment of the energy, cost and greenhouse gas emission benefits of Hydrocarbon Refrigent ACs. For further details please visit our website http://www.fairconditioning.org

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Natural Refrigerant Central AC Systems

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R290 Central AC System

- **Church House in Westminster Abbey**, built to commemorate Queen Victoria's golden jubilee
- 600kW air-cooled water chiller R290 refrigerant - supplied by Earthcare for comfort air conditioning
- Achieves minimized environmental impact through combination of natural refrigerants and optimal energy efficiency

R290 Chiller installed at Church House, Westminster Abbey

Source: 1. Natural Gas, CIBSE Journal, June 12 ; 2. Case Study, Church House, Westminster Abbey – Nicholas Cox, Earthcare

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R290 Central AC System

Savings Achieved

Performance Metric	R290 Chiller	Conventional HFC Chiller
Energy Use (kWh/year)	225,900	332,400
COP	4.15	2.82
Running Cost (£/year)	14,231	20,941
Percentage Savings	21.2%	

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11. References

1. Hydrocarbon Refrigerants For Room Air Conditioners, Daniel Colbourne, for GIZ Proklima, March 2011
2. Barriers to the use of low GWP refrigerants in developing countries and opportunities to overcome these – Barriers Report, UNEP, UNIDO, Daniel Colbourne, Rajendra Shende, 2011. http://www.unep.fr/ozonaction/information/mmcfiles/7476-e-Report-low-WPbarriers.pdf
3. "Refrigerant Data Summary", James M. Calm and Glenn C. Hourahan
4. Standard 34 – ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers)
5. Explosive Limits of different refrigerants - http://www.mathesongas.com/pdfs/products/Lower-(LEL)-&-Upper-(UEL)-Explosive-Limits-.pdf
6. Installation and service manual- Models: GWC09AA - K5NNA6A ", GREE, Giz deutsche gesellschaft für internationale zusammenarbeit (giz) gmbh.
7. "Experimental Assessment of HC-290 as a Substitute to HCFC-22 in a Window Air Conditioner", DR. ATUL S. PADALKAR, DR. SUKUMAR DEVOTTA, Proklima Natural Refregerents, PP No 209-219
8. Guidelines for the safe use of Hydrocarbon Refrigerants, Deutsche Gesellschaft für, German Technical Cooperation – Programme Proklima
9. United States Department of Labor – Hazardous (Classified) Locations - http://www.osha.gov/doc/outreachtraining/htmlfiles/hazloc.html

References:

10 BEE, GENERAL ASPECTS OF ENERGY MANAGEMENT AND ENERGY AUDIT, Chapter – 2 Energy Conservation Act, 2001and Related Policies

11. National Mission for Enhanced Energy Efficiency, PPT by S.P.Garnaik, Bureau of Energy Efficiency
12. National Mission for Enhanced Energy Efficiency, PPT by S.P.Garnaik, Bureau of Energy Efficiency
13. no2co2 research based on COP-15 Commitments of reducing GHG Intensity of GDP by 25% by 2020
14. BEE, GENERAL ASPECTS OF ENERGY MANAGEMENT AND ENERGY AUDIT, Chapter – 1 Energy Scenario
15. Central Electricity Authority, Operation Performance Monitoring Division, Electricity Generation during the month of September'12 and during the period April'12-September'12, Page 5
16. IPCC Fourth Assessment Report: Climate Change 2007
17. Velders et al.: The importance of the Montreal Protocol in protecting climate, Guus J. M. Velders, , Stephen O. Andersen, John S. Daniel, David W. Fahey, and Mack McFarland, 4814 – 4819, Proceedings of the National Academy of Sciences, March 20, 2007, vol. 104, no. 12