

# **Copper in Air Conditioners & Refrigeration**

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On behalf of MetalsPlus

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# Legal Statement

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**The purpose of the information in the following presentations is to guide ICA programs and provide members with information to make independent business decisions.**

# Antitrust Guidelines for Copper Industry Trade Association Meetings

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The following guidelines with respect to compliance with antitrust laws of the United States, Japan and European Community<sup>1</sup> are intended to govern the conduct of participants in copper industry trade association meetings, both at the meeting itself and in informal discussions before or after the formal meeting.

**Price:** Competitors should not discuss future prices (including terms of sale) of their products. There is no blanket prohibition against the mention of or reference to current or past prices but limits must be observed. Such references or mentions should occur only when necessary in connection with the development of association programs. For example, reference to a particular price level in comparing the cost of a copper product to a competing product is permitted. Whenever possible, such references should be discussed in advance with legal counsel.

**Competitive Information:** Competitors should not discuss the market share of a particular copper producer or copper fabricator's products. Furthermore, nothing should be said at a meeting which could be interpreted as suggesting prearranged market shares for such products or producer production levels. The overall market share of copper products may be discussed with regard to competition with non-copper products and general market acceptance.

**New Products:** Competitors should not encourage or discourage the introduction of a new product by another competitor or reveal a particular copper company's plans to change the production rate of an existing product or to introduce a new product. No company should disclose to another company whether it is in a position to make or market a new product. New products may be discussed in a technical manner or from the standpoints of competition with non-copper products and general market acceptance.

In addition, proposed methods for and results of field and laboratory testing can be considered.

**The Role of Legal Counsel:** Legal counsel attends association meetings to advise association staff and other meeting attendees regarding the antitrust laws and to see that none of the matters discussed or materials distributed raise even the appearance of antitrust improprieties. During the course of a meeting, if counsel believes that the discussion is turning to a sensitive or inappropriate subject, counsel will express that belief and request that the attendees return the discussion to a less sensitive area.

A paper entitled 'Copper Industry Trade Associations and Antitrust Laws' is available upon request. 10/92, 5/93, 10/10

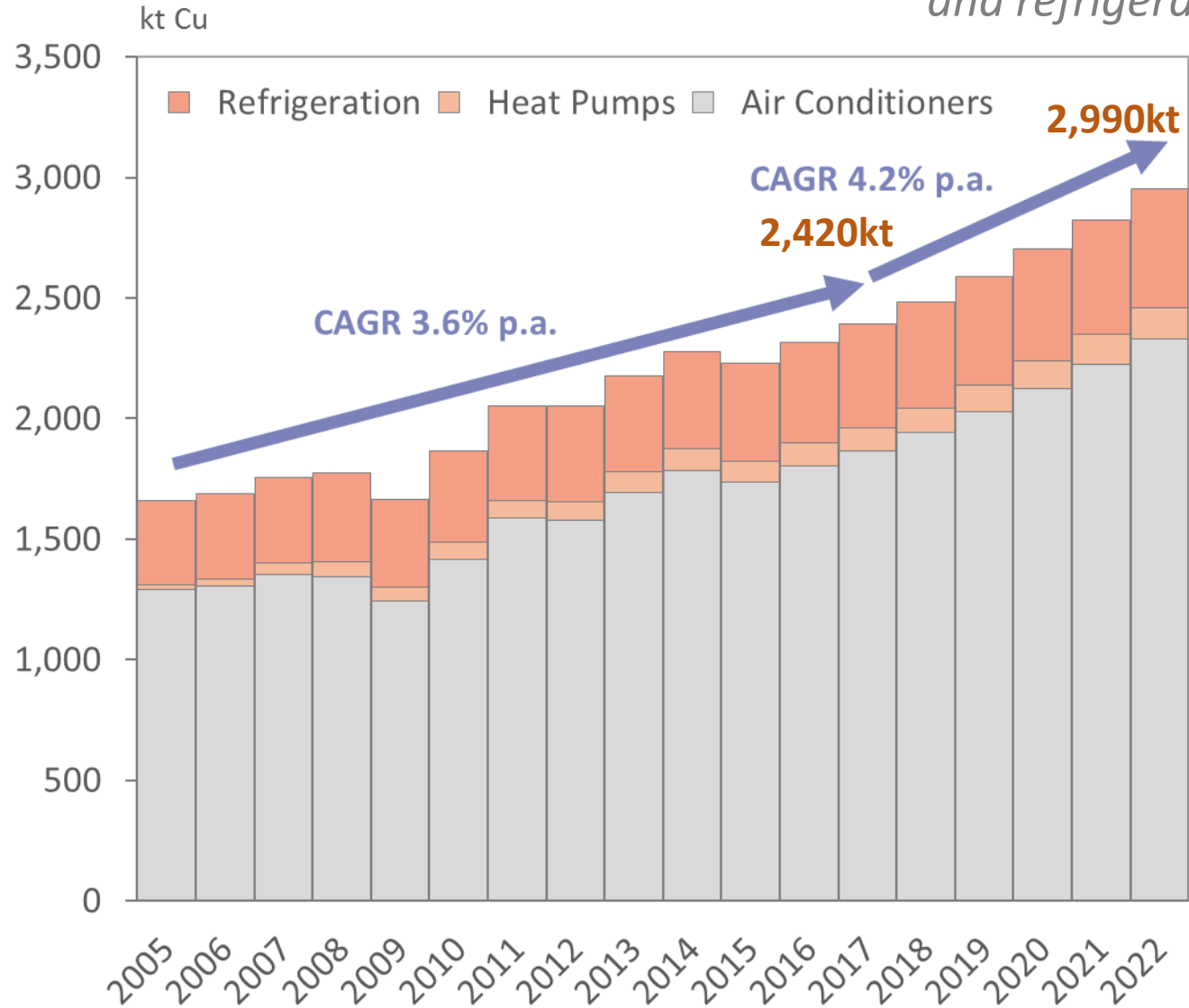
1. Other foreign competition laws apply to International Copper Association, Ltd. (ICA)'s activities worldwide.

## Summary

- The market of Air Conditioners & Refrigeration is growing quickly in value, volume and cooling capacity
- Demand for copper in this market is growing by 3.6% p.a. (2005-17). Growth is expected to accelerate to 4.2% p.a. (2017-22)
- A key driver is rising unit volume, in part related to increasing GDP per capita in the developing world – mostly located in tropical and arid climatic zones – with a strong need for cooling
- Another driver is a trend towards more eco-friendly air conditioners that cut greenhouse emission with better refrigerants and greater energy efficiency. Both can raise material intensity for copper
- In practice, design improvements limit materials intensity gains, but new copper solutions offer superior performance, and secure copper's role in what remains a strongly growing market for Air Conditioners & Refrigeration.

# Copper Use in HVAC(R) 2005 to 2022

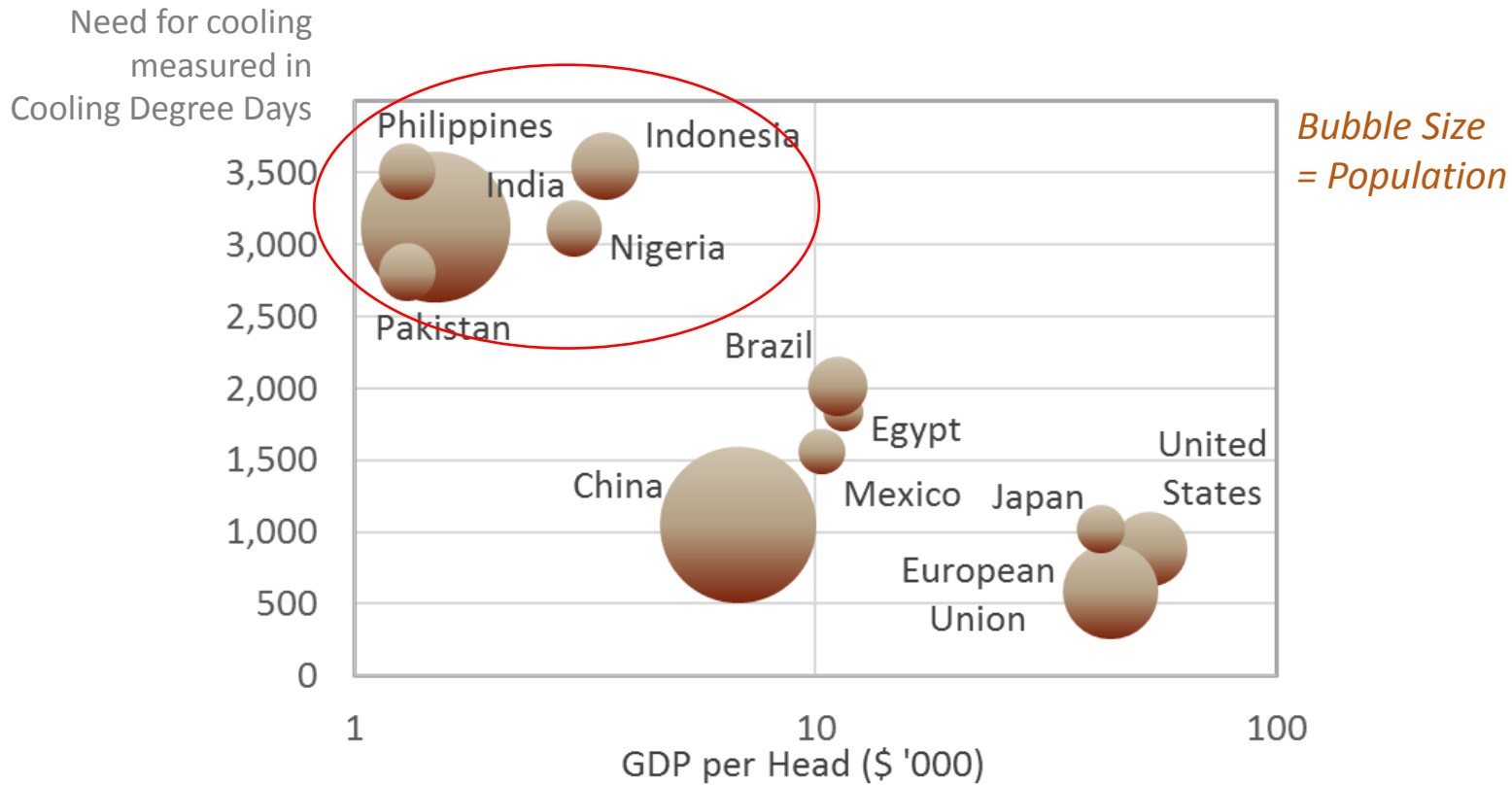
*Copper use is accelerating in the air-conditioning and refrigeration market*



## Key driver of the market is the need for cooling

*The need for cooling exists in highly populated countries with low GDP per capita*

### Wealth, Population, and Need for Cooling

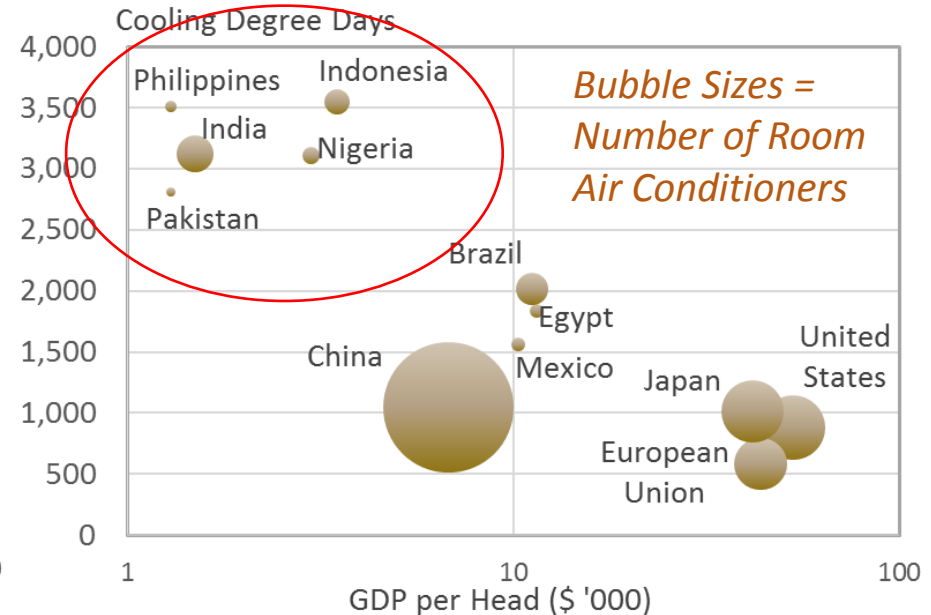
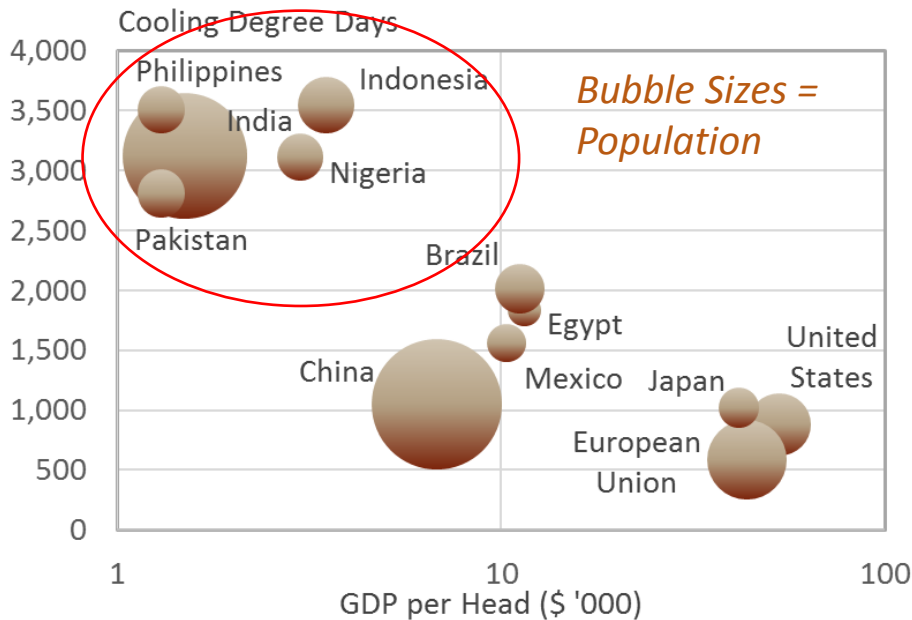


Cooling Degree Day (CDD) is a measure of potential demand for cooling, normalised to 18 °C (65 °F).

Source: Climate Analysis Indicators Tool (CAIT): World Resources Institute

*Comparing the need for cooling with the number of installed A/C units reveals significant market potential*

## Need for Cooling and Installed Air Conditioning Units



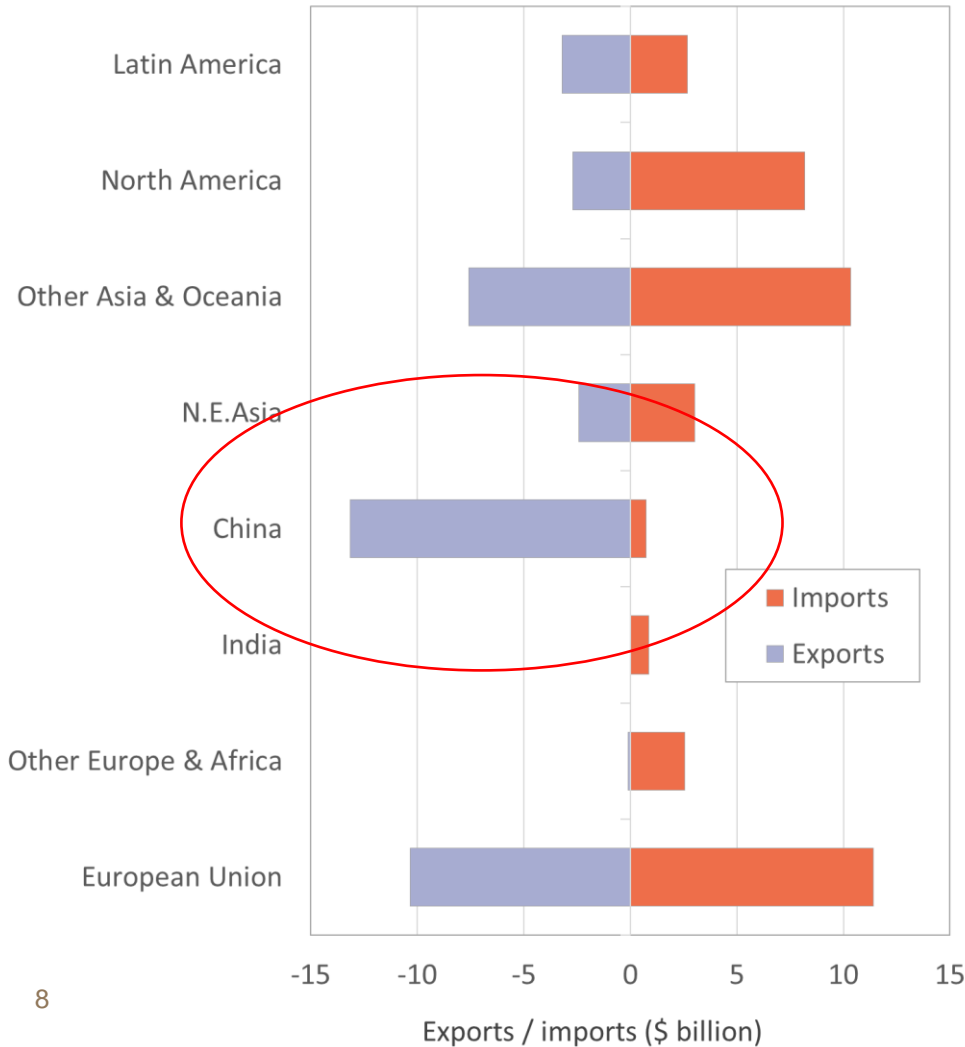
Cooling Degree Day (CDD) is a measure of potential demand for cooling, normalised to 18 °C (65 °F).

Source: Climate Analysis Indicators Tool (CAIT): World Resources Institute

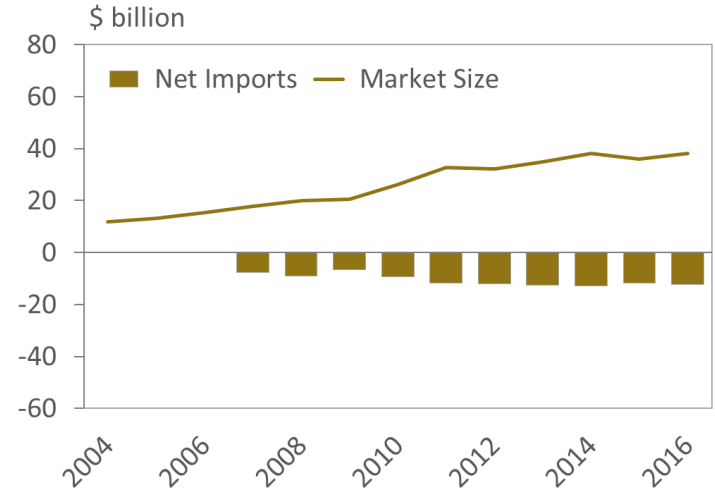
# China strongly impacts the design of Air conditioners

*China represents ca. one-third of the global demand and one-half of production of A/C units*

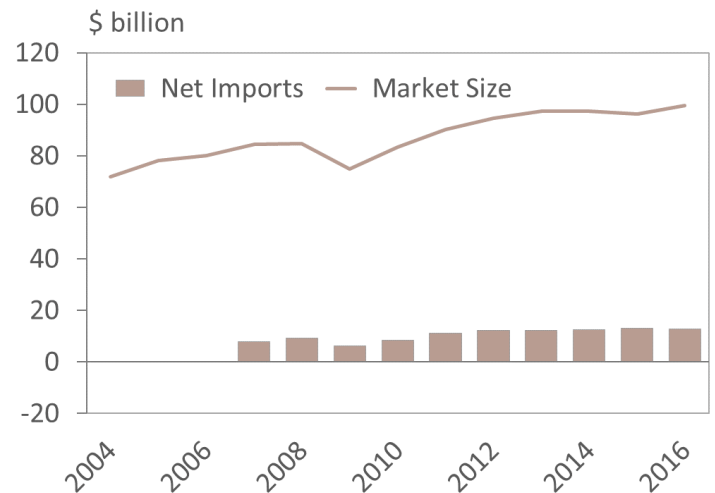
**Trade in Air Conditioners & Parts in 2016**



**China Trade & Market Trend**



**Rest of the World Trade & Market Trend**





## Diverse Aircon & Refrigeration Market in 2017

*The market consists of a wide variety of devices*

### Room Air Conditioners

\$ Million

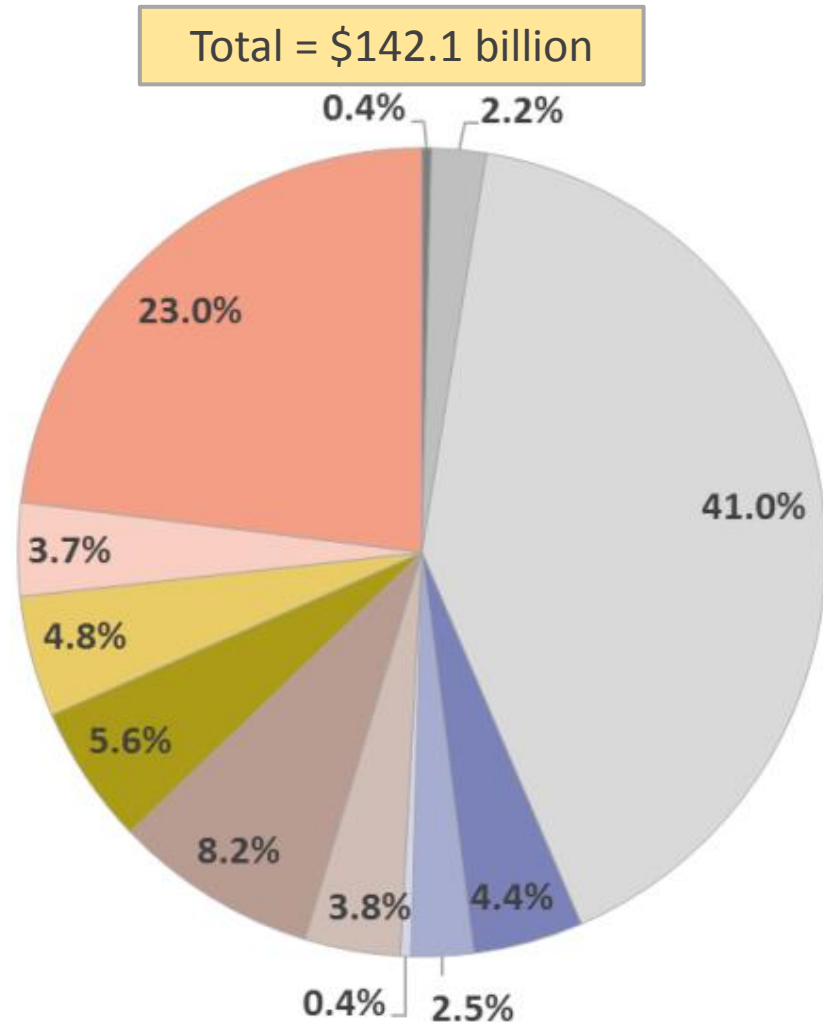
Portable	543
Window	3,096
Ductless Room Splits	58,264

### Multi-Room, Commercial & Industrial Aircon

US Ducted Splits	6,266
Other Splits	3,516
Indoor Packaged	603
Rooftop & Misc.	5,436
Variable Refrigerant Flow	11,609
Chillers	7,906
Airside Equipment	6,884

### Related Markets

Heat Pumps	5,304
Refrigeration	32,713



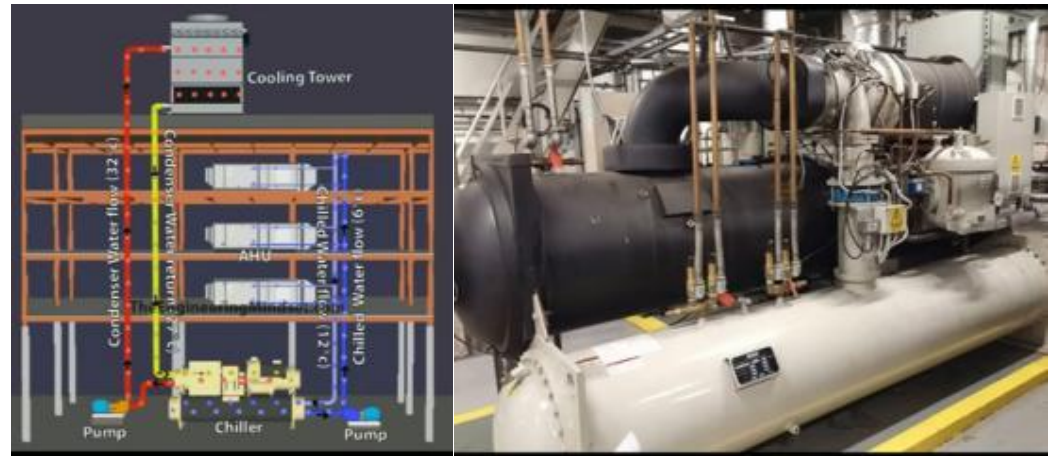
# HVAC(R) Types in the Aircon & Refrigeration Market

*The market consists of a wide variety of devices*

Ductless Split Room Air Conditioner



Chiller Based System (A Chiller & Whole Building Graphic)



Packaged System (Outside Condenser & Inside Parts)



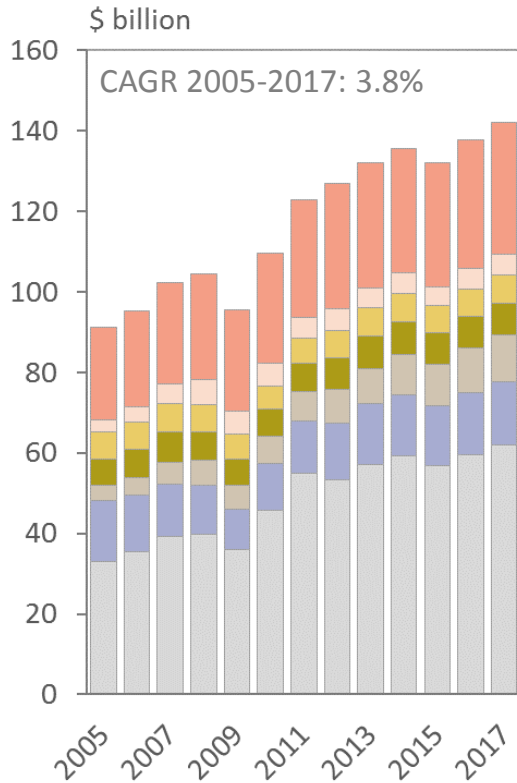
Refrigeration (Stack of Condensers & Display Cabinets)



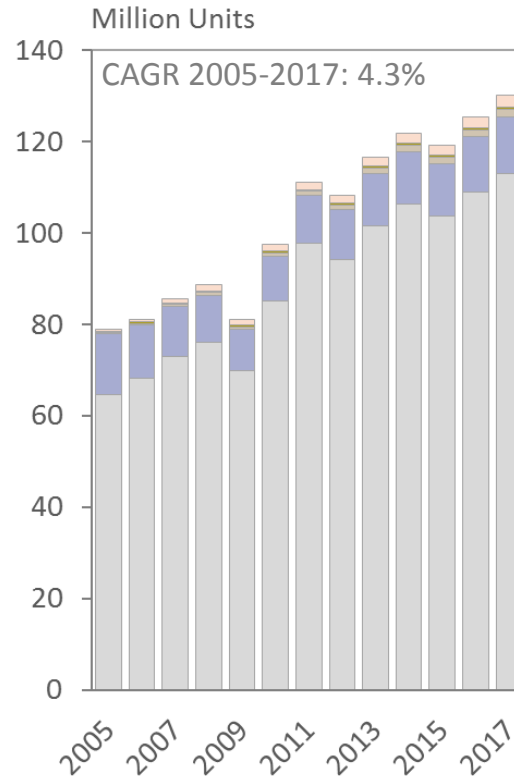
# Market Measurement and Past Developments

*The market is growing according to key measurements such as value, volume and cooling capacity*

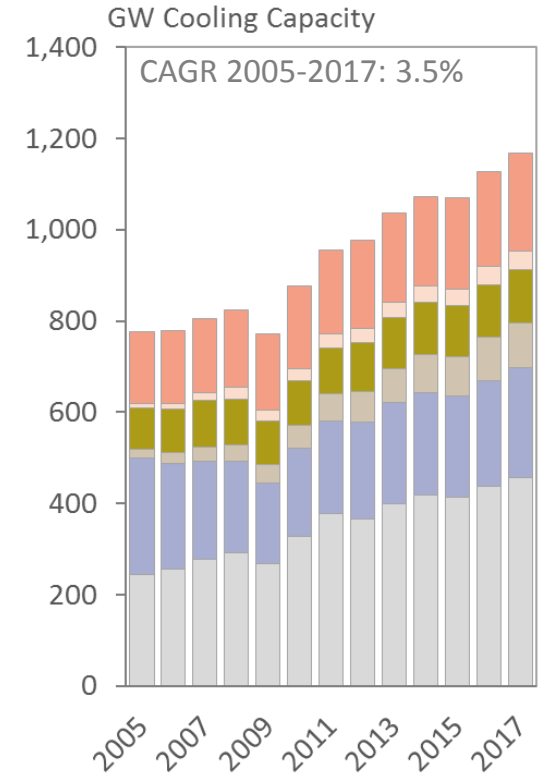
## Value



## Number of Units



## Cooling Capacity



- Comm. & Ind. Refrigeration
  Non Reversible Heat Pumps
  Airside Equipment
  Chillers
- Variable Refrigerant Flow
  Packaged Types
  Room Air Conditioners

Note: Data for airside equipment shown only for value. Unit data not available for refrigeration

## Use of Copper Tube & Winding Wire

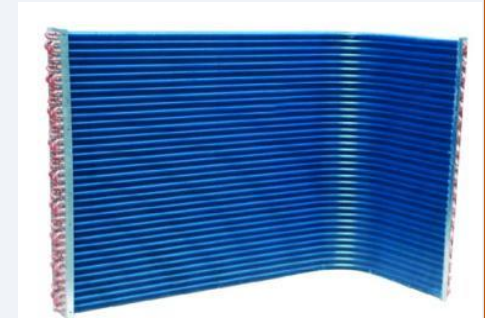
*The air conditioning and refrigeration market uses copper in form of tubes and winding wire*

### Fabricated Copper Forms

#### Tube



Heat Exchangers



#### Winding Wire



Motors



## Copper and Copper Equivalent Use in 2017

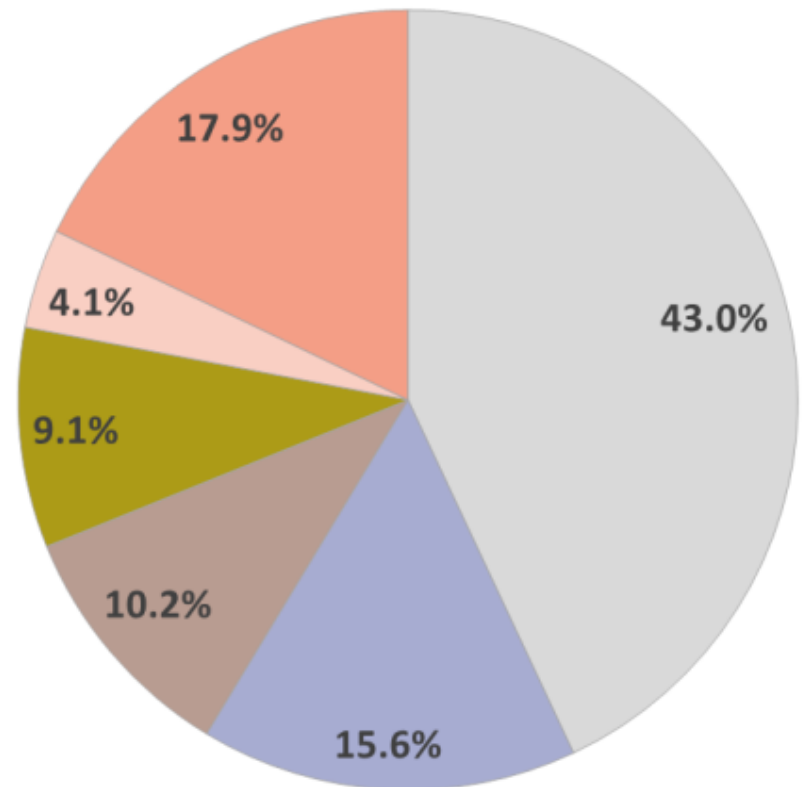
*In 2017 copper retains 83% penetration for applications in the market where copper could be used*

	Copper kt	Other kt
Room Air Conditioners	1,039	92
Packaged Types	379	201
VRF	247	7
Chillers	221	21
Heat Pumps	100	5
Refrigeration	431	170

Copper equivalent (all materials where copper could be used) = 2.91 Mt  
Copper actual use = 2.42 Mt

**Copper retains 83% application penetration (without US and refrigeration it is 94%)**

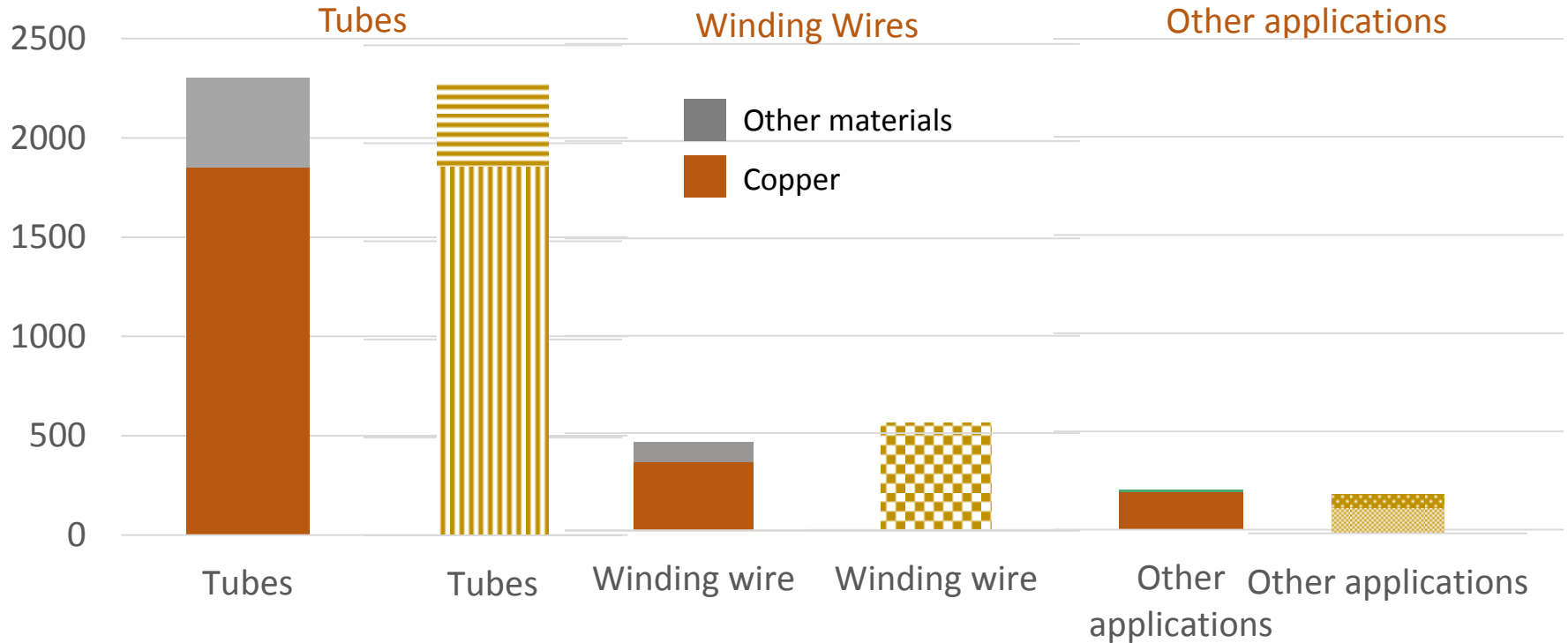
Copper 2.42 Mt use by type of application in 2017



# Copper and Copper Equivalent Use by Fabricated Form

*Copper tubes and within these heat exchanger tubes are the copper fabricated forms most required by the market*

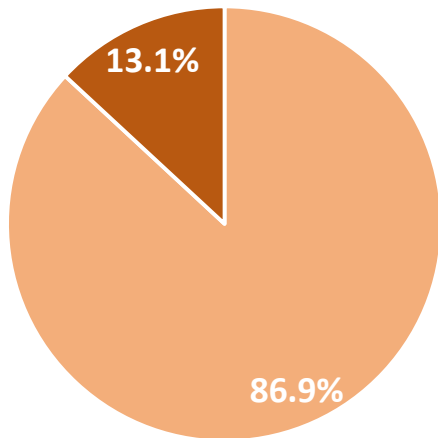
Use of Copper and Other Materials by Applications and by Fabricated Form



Fabricated Forms	Material	Percentage
Connecting Tube	Copper	18%
Heat X Change Tube	Copper	82%
Winding Wire	Copper	100%
Other forms	Copper	35%
Energy wiring	Copper	65%

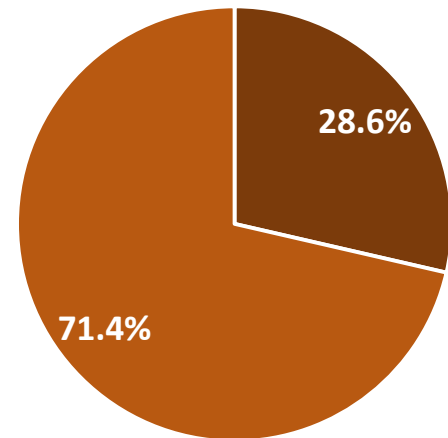
*The greenhouse gas emissions by the cooling sector is significantly increased by leaking refrigerants*

**All Greenhouse Gas Emissions**



 Cooling Sector  Other Sectors

**Greenhouse Gas Emissions from Cooling Sector**



 Direct Emissions  Indirect Emissions

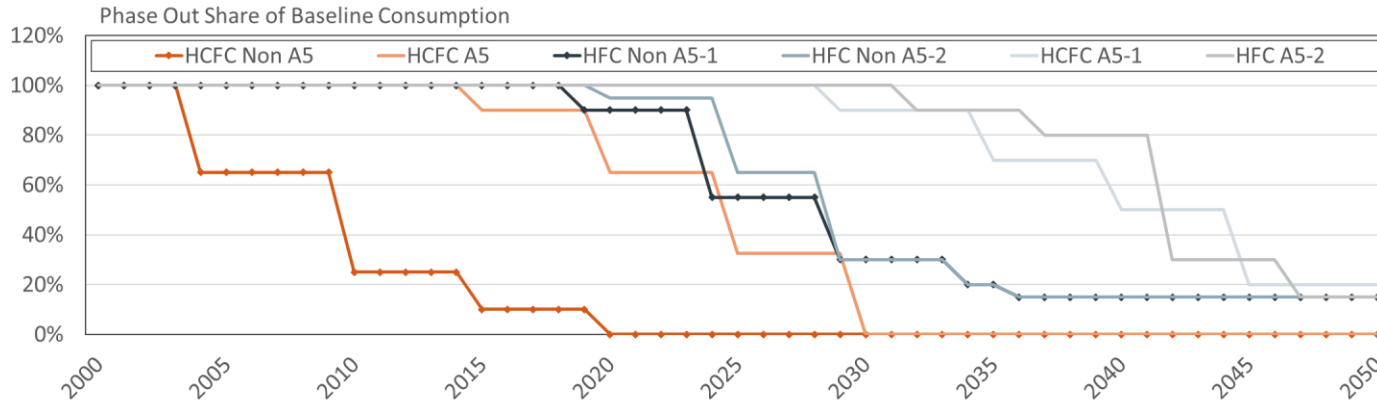
Direct Emissions result from leaking refrigerants

Indirect Emissions result from fossil-fuel burning electricity generation

Source: Green Cooling Initiative Website

*Copper works well with new, more environmental friendly refrigerants*

Planned Phase-Out of HCFCs and HFCs Under the Montreal Protocol



Montreal Protocol sets out the plan to phase out the use of ozone depleting substances (ODSs) in refrigeration etc.

Merits & Demerits of Alternative Categories of Refrigerant

	Current HFCs	Low GWP HFCs	Blended HFOs	Carbon Dioxide	Hydro-carbons	Ammonia
Global Warming Potential	Poor	Moderate	Quite Good	Quite Good	Quite Good	Quite Good
Energy Efficiency	Quite Good	Quite Good	Quite Good	Fairly Poor	Quite Good	Quite Good
Flamability	Quite Good	Quite Good	Quite Good	Quite Good	Fairly Poor	Fairly Poor
Toxicity	Quite Good	Quite Good	Quite Good	Quite Good	Quite Good	Poor
Refrigerant Cost	Quite Good	Quite Good	Poor	Quite Good	Quite Good	Quite Good
Compressor Cost	Quite Good	Quite Good	Quite Good	Poor	Quite Good	Quite Good
System Cost	Quite Good	Quite Good	Moderate	Poor	Fairly Poor	Quite Good

Good    
  Moderate    
  Fairly Poor  
 Quite Good    
  Poor

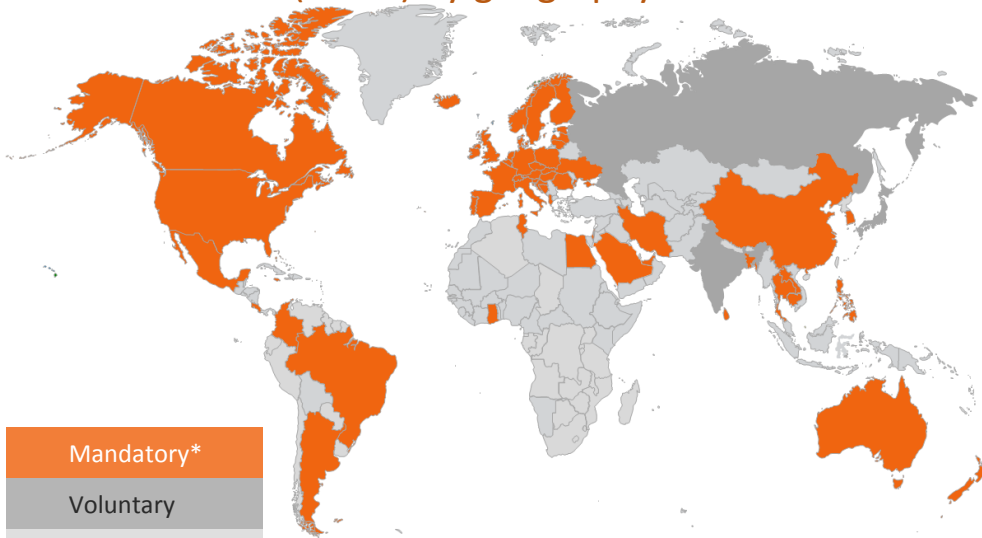
New refrigerants are more environmental friendly but often have issues with flammability, toxicity or high costs.

Copper works well with new refrigerants for example in the high pressure environment of carbon dioxide, and its mechanical and thermal properties make it the logical choice where flammability is an issue.



*Minimum Energy Performance Standards (MEPs) are well in implemented but are on different efficiency levels*

## Minimum Energy Performance Standards (MEPs) by geography



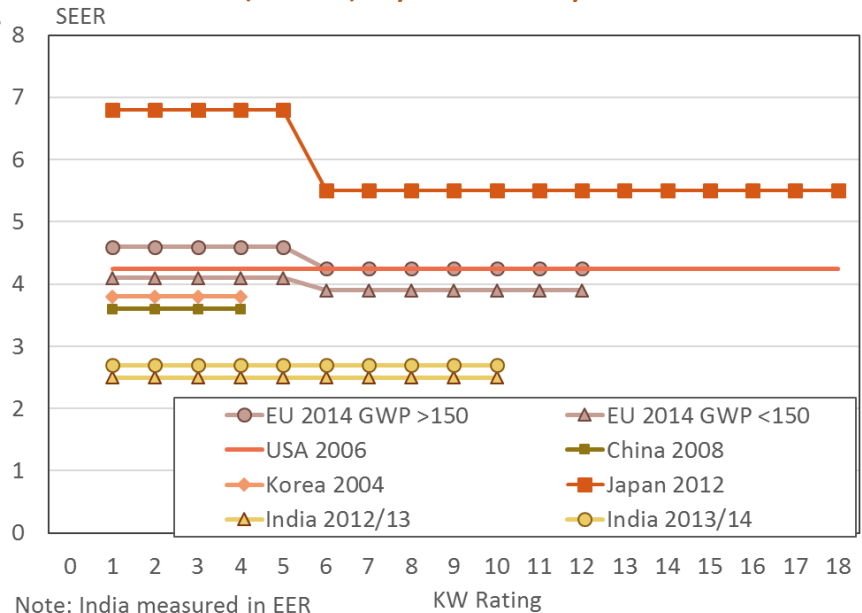
Mandatory*
Voluntary
No policy in place or no data found

\*For the EU, there are no MEPS but a mandatory labelling programme.

However, these Minimum Energy Performance Standards are in different countries on various efficiency levels and well below of what is possible.

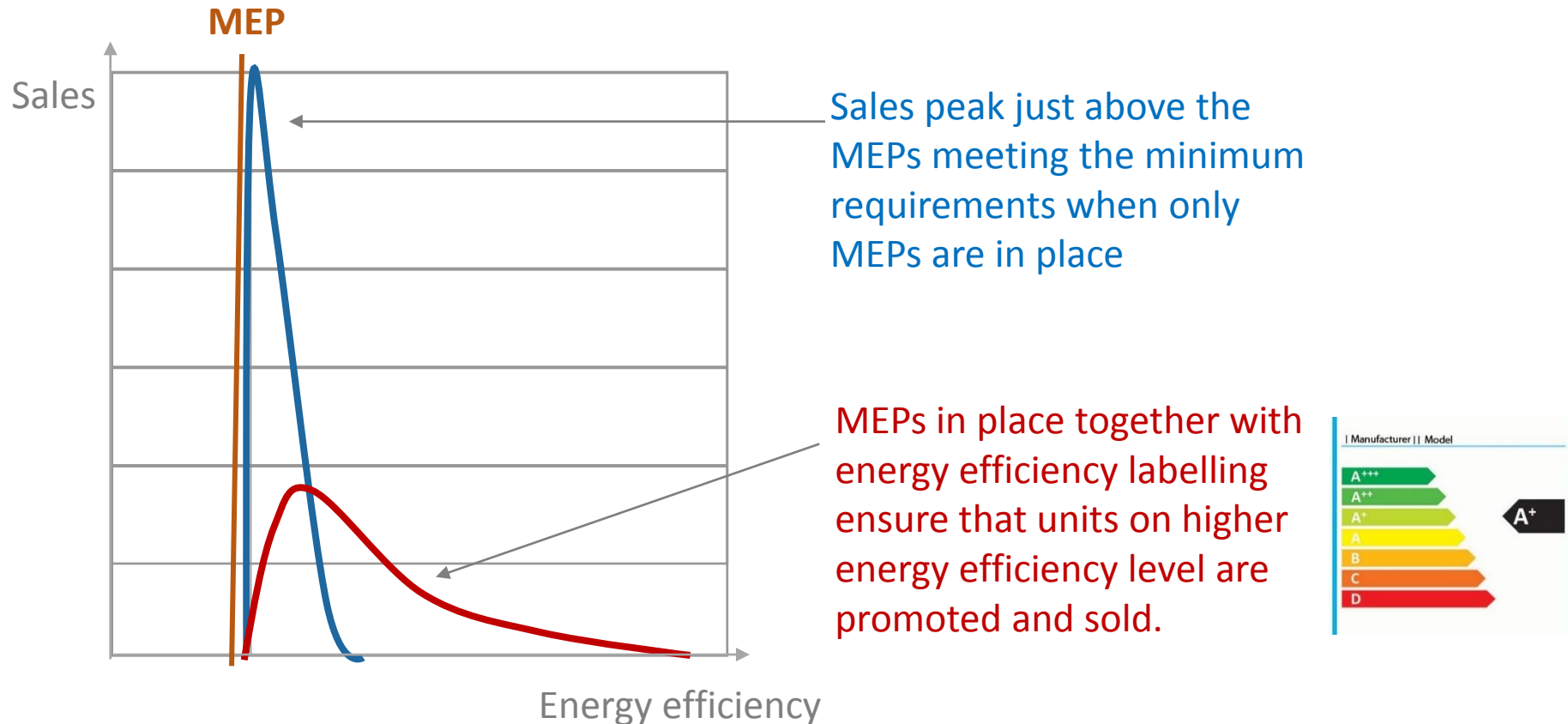
The majority of countries have either mandatory or voluntary Minimum Energy Performance Standards in place for room air conditioners.

## Minimum Energy Performance Standards (MEPs) by efficiency levels



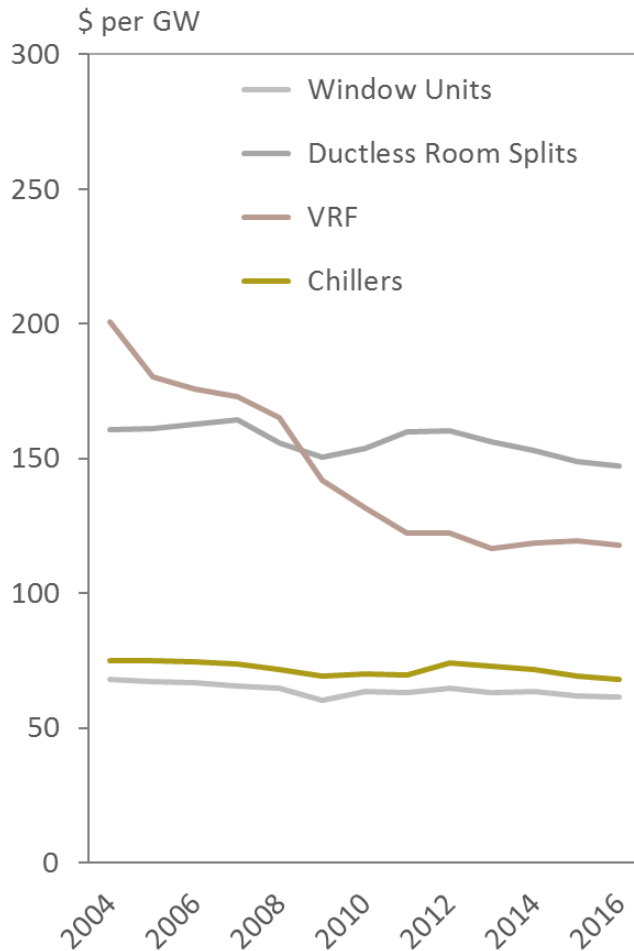
*MEPs and energy efficiency labelling together drive the production of air conditioners with better energy efficiency*

## Sales of room air conditioners on different energy efficiency levels



*The price of air conditioners is on a declining trend while increasing energy efficiency performance is required*

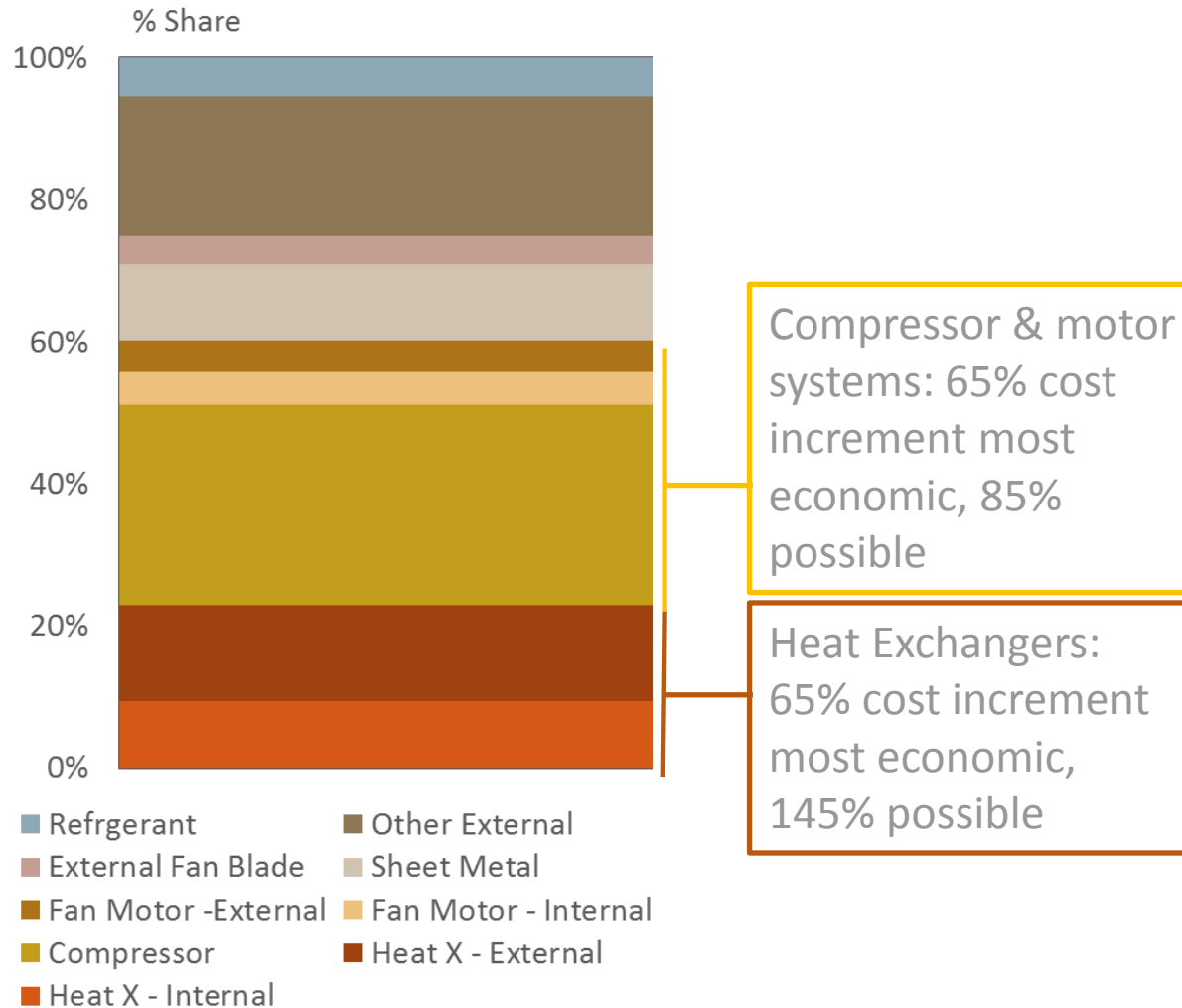
**Prices of Air Conditioner  
Performance by Types (\$ per GW)**



- Strong competition drives the retail price of the air conditioners' cooling performance downwards.
- At the same time, higher energy efficiency requirements drive costs upwards.
- Better cooling performance and energy efficiency delivered at lower costs requires constant technological upgrades.

*The largest cost improvements result from upgrading the compressor & motor systems and the heat exchangers*

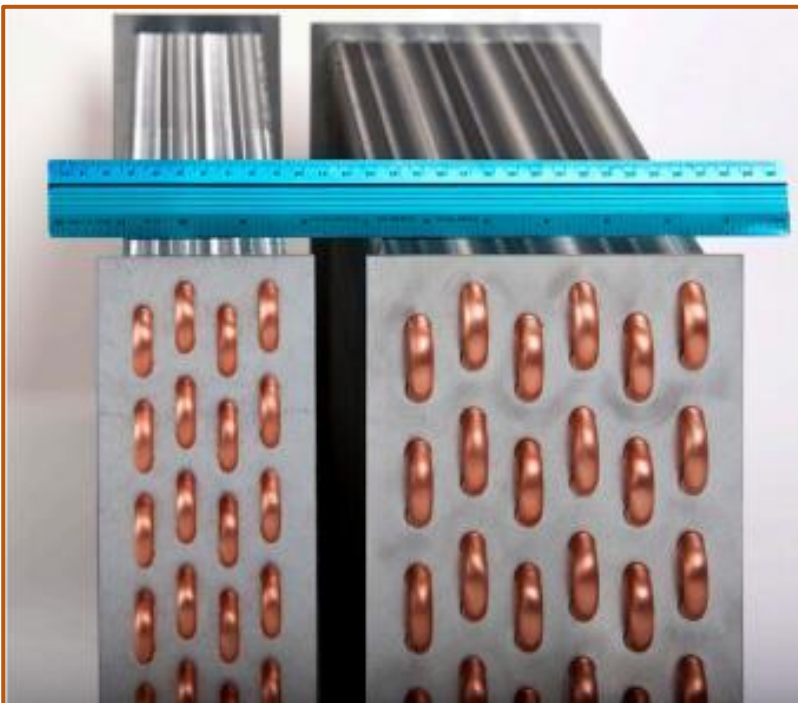
## Efficiency Upgrade Focus on the Copper-Containing Parts\*



Note: \* The figures are based on India research on a 5.25 KW split air conditioner raising efficiency from 2.8 to 4.0 ISEER by Berkeley Lab, without new cost saving technology

*Copper offers superior technology to achieve technological upgrades in heat exchangers*

### Microgroove Small Diameter Copper Tube

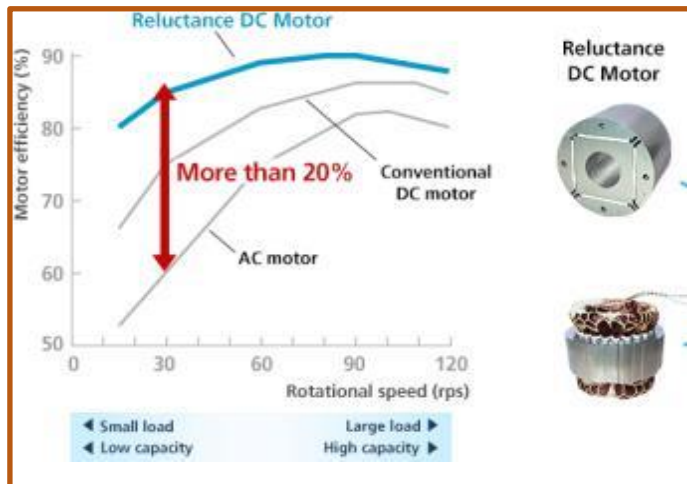


### Heat Exchangers

- Heat exchange performance has improved dramatically as a result of inner grooving of copper tube, a process optimised over the past 20 years
- Smaller diameter thinner wall copper tube is used, common down to 5 mm compared to 9.52 mm for earlier designs
- Modern 'Microgroove' heat exchangers save copper material (up to 45%), are efficient in heat exchange, use less refrigerant, and can work with high pressure refrigerants

*Copper is the material of choice for improved motor efficiency*

### Inverter Models with BLDC Motors Motor Driven Systems



- Electronic control of motor speed and torque by varying motor input frequency is achieved using variable speed drive (VSD) in 'inverter' air conditioners
- VSD is used with compressors, also fans
- Traditional AC motors themselves have been upgraded using superior electrical steels, better windings, 6 or 8 pole rather than 4 pole structure and other design improvements
- Brushless DC motors (BLDC) have also made inroads and can be 80% or more efficient
- BLDC motors are well suited to working with VSD, as they use DC input directly rather than needing it re-converted to AC
- Efficient motors are more likely to have copper stator windings than the inefficient types

## Copper Use by HVAC(R) Type 2010-2022

*Copper use in the air-conditioning & refrigeration market is expected to increase at 4.2% p.a. over next five years*

