Copper in Air Conditioners & Refrigeration

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On behalf of MetalsPlus

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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

The following guidelines with respect to compliance with antitrust laws of the United States, Japan and European Community\(^1\) 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

![Graph showing copper use in HVAC(R) 2005 to 2022](image)

- **2,420 kt** (CAGR 3.6% p.a.)
- **2,990 kt** (CAGR 4.2% p.a.)
Key driver of the market is the need for cooling

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

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.

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.
**Diverse Aircon & Refrigeration Market in 2017**

*The market consists of a wide variety of devices*

### Room Air Conditioners

<table>
<thead>
<tr>
<th>Type</th>
<th>$ Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portable</td>
<td>543</td>
</tr>
<tr>
<td>Window</td>
<td>3,096</td>
</tr>
<tr>
<td>Ductless Room Splits</td>
<td>58,264</td>
</tr>
</tbody>
</table>

### Multi-Room, Commercial & Industrial Aircon

<table>
<thead>
<tr>
<th>Type</th>
<th>$ Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Ducted Splits</td>
<td>6,266</td>
</tr>
<tr>
<td>Other Splits</td>
<td>3,516</td>
</tr>
<tr>
<td>Indoor Packaged</td>
<td>603</td>
</tr>
<tr>
<td>Rooftop &amp; Misc.</td>
<td>5,436</td>
</tr>
<tr>
<td>Variable Refrigerant Flow</td>
<td>11,609</td>
</tr>
<tr>
<td>Chillers</td>
<td>7,906</td>
</tr>
<tr>
<td>Airside Equipment</td>
<td>6,884</td>
</tr>
</tbody>
</table>

### Related Markets

<table>
<thead>
<tr>
<th>Type</th>
<th>$ Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pumps</td>
<td>5,304</td>
</tr>
<tr>
<td>Refrigeration</td>
<td>32,713</td>
</tr>
</tbody>
</table>
HVAC(R) Types in the Aircon & Refrigeration Market

The market consists of a wide variety of devices.

Ductless Split Room Air Conditioner

Packaged System (Outside Condenser & Inside Parts)

Chiller Based System (A Chiller & Whole Building Graphic)

Refrigeration (Stack of Condensers & Display Cabinets)
The market is growing according to key measurements such as value, volume and cooling capacity.

### Value

<table>
<thead>
<tr>
<th>Year</th>
<th>Value (billion $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>60</td>
</tr>
<tr>
<td>2007</td>
<td>80</td>
</tr>
<tr>
<td>2009</td>
<td>100</td>
</tr>
<tr>
<td>2011</td>
<td>120</td>
</tr>
<tr>
<td>2013</td>
<td>140</td>
</tr>
<tr>
<td>2015</td>
<td>160</td>
</tr>
<tr>
<td>2017</td>
<td>180</td>
</tr>
</tbody>
</table>

CAGR 2005-2017: 3.8%

### Number of Units

<table>
<thead>
<tr>
<th>Year</th>
<th>Units (Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>40</td>
</tr>
<tr>
<td>2007</td>
<td>60</td>
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<tr>
<td>2009</td>
<td>80</td>
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<tr>
<td>2011</td>
<td>100</td>
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<tr>
<td>2013</td>
<td>120</td>
</tr>
<tr>
<td>2015</td>
<td>140</td>
</tr>
<tr>
<td>2017</td>
<td>160</td>
</tr>
</tbody>
</table>

CAGR 2005-2017: 4.3%

### Cooling Capacity

<table>
<thead>
<tr>
<th>Year</th>
<th>GW Cooling Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>200</td>
</tr>
<tr>
<td>2007</td>
<td>400</td>
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<tr>
<td>2009</td>
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<td>2011</td>
<td>800</td>
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<tr>
<td>2013</td>
<td>1000</td>
</tr>
<tr>
<td>2015</td>
<td>1200</td>
</tr>
<tr>
<td>2017</td>
<td>1400</td>
</tr>
</tbody>
</table>

CAGR 2005-2017: 3.5%

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
- Winding Wire

- Heat Exchangers
- Motors
In 2017 copper retains 83% penetration for applications in the market where copper could be used.

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%)

Note: “All Material” includes all items that may be made of copper.
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

- **Tubes**
  - Copper: 82%
  - Connecting Tube: 18%

- **Winding Wires**
  - Winding Wire: 100%

- **Other applications**
  - Other forms: 35%
  - Energy wiring: 65%
The greenhouse gas emissions by the cooling sector is significantly increased by leaking refrigerants.

**HVAC(R) & GHG Emissions**

**All Greenhouse Gas Emissions**
- Cooling Sector: 13.1%
- Other Sectors: 86.9%

**Greenhouse Gas Emissions from Cooling Sector**
- Direct Emissions: 28.6%
- Indirect Emissions: 71.4%

Direct Emissions result from leaking refrigerants.
Indirect Emissions result from fossil-fuel burning electricity generation.

Source: Green Cooling Initiative Website
New, More Environment-Friendly Refrigerants

Copper works well with new, more environmental friendly refrigerants

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

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 implemented but are on different efficiency levels.

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

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

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

Note: India measured in EER

**Minimum Energy Performance Standards (MEPs) by geography**

**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

- MEP

**Sales peak just above the MEPs meeting the minimum requirements when only MEPs are in place.**

- MEPs in place together with energy efficiency labelling ensure that units on higher energy efficiency level are promoted and sold.
The price of air conditioners is on a declining trend while increasing energy efficiency performance is required.

- 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.
Areas for cost improvements

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

Efficiency Upgrade Focus on the Copper-Containing Parts*

- Compressor & motor systems: 65% cost increment most economic, 85% possible
- Heat Exchangers: 65% cost increment most economic, 145% possible

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 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.

**Heat Exchangers**
Copper-based design updates

Copper is the material of choice for improved motor efficiency

Inverter Models with BLDC Motors

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