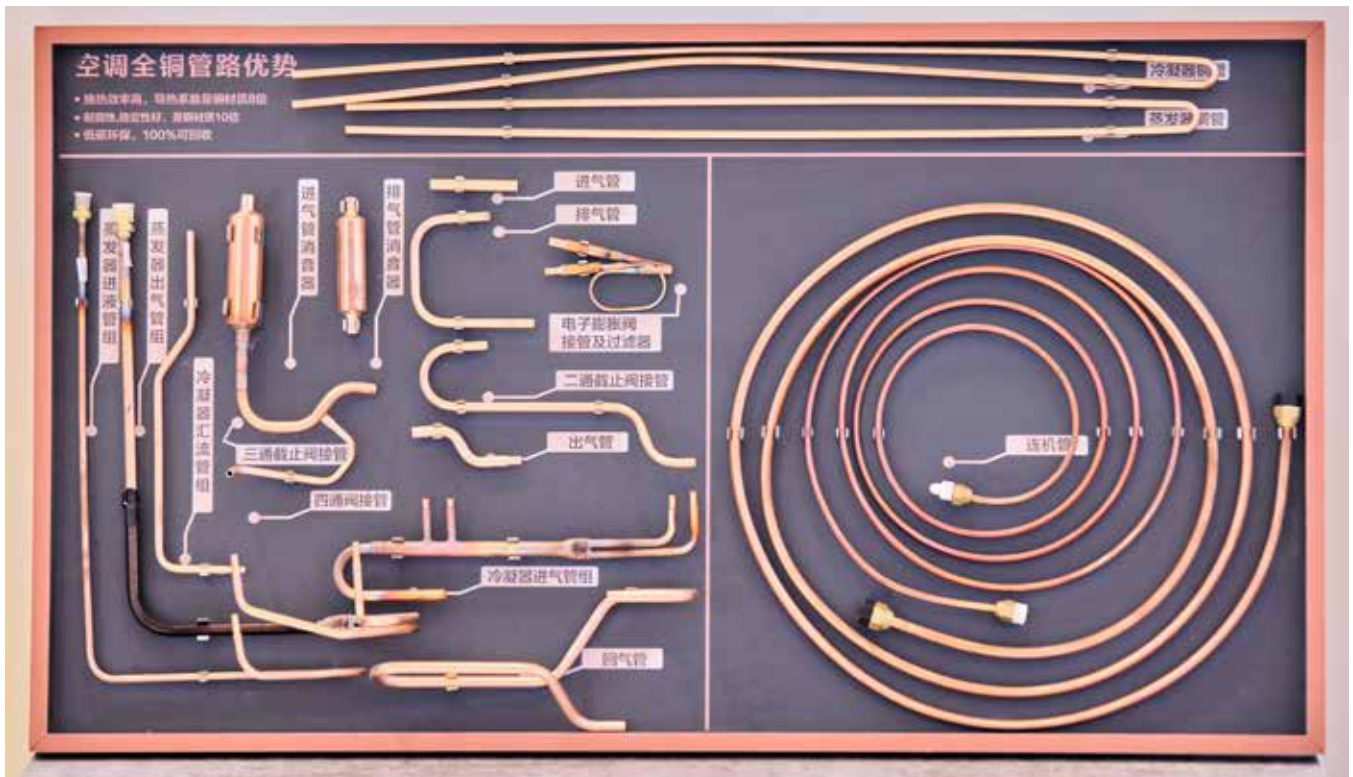




Copper Shines at AWE2025: How Copper Is Driving the Low-Carbon Transformation in the Global Appliance Industry

The Appliances & Electronics World Expo, also known as AWE, (<https://en.awe.com.cn/>) is an awesome platform for global dialogue on low-carbon technology.

AWE2025 is the largest such industry event in Asia. As the global home appliance and consumer electronics industries strives for transformation under carbon-neutral goals, its 2025 theme "AI Technology, AI Life" reflects on the growing presence of artificial intelligence in appliances and consumer electronics.

Focusing on low-carbon technologies and sustainable development, more than 800 multinational enterprises and leading local companies assembled their exhibits within the Shanghai New International Expo Center for what could best be described as a symphony of technology and

environmental sustainability.

One awe-inspiring instrument in this symphony orchestra was the "Copper Inside" exhibition, which was organized by the International Copper Association China Office. The top of mind question for more than 200,000 visiting professionals at AWE2025 was How to balance consumer upgrades and environmental constraints in the face of growing demand for more sustainable living practices?

Naturally, the "Copper Inside" exhibition garnered a great deal of attention with its theme of "Copper Builds a Green Low-Carbon Life." The critical importance of copper materials in appliance design was exemplified by two products: (1) the Casarte 100% full copper refrigerant tube air conditioner and (2) Midea's R290 refrigerant small-diameter copper tube heat exchanger technology.

These products were on display at the "Copper Inside" exhibit revealing an often overlooked but critically important reality: Although traditional copper materials have been used for decades in appliances and consumer electronics, copper now plays a central role in the low-carbon revolution of the home appliance industry. The new role of copper is due to its outstanding physical properties and environmental advantages as outlined in this article.

Copper materials are key to driving the home appliance sector's low-carbon, energy-efficient and sustainable development. The new role of copper is a victory for materials science and an admirable example of industry-wide collaboration and innovation. As copper steps out from backstage, taking center stage in the limelight, it is transformed into the "green metal."

An Air Conditioner with 100 Percent Full Copper Refrigerant Tubes

The Casarte AC on display at the “Copper Inside” exhibit demonstrates how a material revolution is reshaping industry standards. This AC shows how the copper inside provides

- (1) corrosion resistance,
- (2) superior thermal conductivity,
- (3) health and environmental protection

These advantages follow from using 100 percent copper in the refrigerant carrying tubes of the Casarte air-conditioner.

1. Corrosion Resistance: The “Copper Wall” Defines Lifespan

At the center of the “Copper Inside” booth, the Casarte air conditioner proudly displayed the trademark “Industry’s Only ‘Copper Inside’ Authorized 100% Full Copper Refrigerant Tube,” underscoring how the inherent physical properties of copper are actively reshaping industry standards.

Data reveals that copper’s corrosion resistance is more than ten times that of steel, significantly extending the life of air conditioners while preventing refrigerant leakage. This property becomes even more critical in hot and humid climates or coastal environments with high salt content. Traditional steel tubes typically corrode and result in refrigerant leaks after just five to eight years, whereas copper tubes can last 15 to 20 years, thus reducing both the cost of repairs and the environmental risks associated with leakage.

This performance advantage is rooted in copper’s natural passivation property: copper reacts with oxygen in the air to form a dense copper oxide film, effectively preventing moisture and metal ions from penetrating into the bulk metal. Comparative experiments for tubes



in the same acidic environment show that the annual corrosion rate is only 0.001 mm for copper tubes in contrast to 0.01 mm for steel tubes, affirming the immense durability of copper.

2. Thermal Conductivity: Redefining the Technology Benchmark for “Instant Comfort”

Copper boasts an extraordinary thermal conductivity of 401 W/m·K. That’s eight times greater than steel and twice that of aluminum, making copper the ideal material for constructing high-efficiency heat exchange systems.

The Casarte air conditioner uses copper tubing with internal threads, which increases the internal surface area by 30% compared to ordinary smooth tubes, significantly boosting heat transfer efficiency. The improvement in heat transfer efficiency enhances the user experience by reaching the set temperature faster after startup and directly reduces energy consumption. Copper tubes transfer

heat more quickly and efficiently, improving the air conditioner’s cooling and heating performance. During both the cooling and heating processes, copper tubes can rapidly transfer heat from the refrigerant into the air or absorb heat from the air, thereby improving the air conditioner’s efficiency in delivering both cooling and heating.

3. Health and Environmental Protection: Dual Closed Loops from Maternal and Infant Care to Circular Economy

In response to consumer demands for health-conscious home appliances, Casarte allows for healthy living solutions in households with infants. The natural antimicrobial properties of copper have become a key selling point. Research shows that copper surfaces can kill 99.9% of *Escherichia coli* and *Staphylococcus aureus* within two hours, an internationally certified feature by SGS testing and certification company. <https://www.sgs.com/en/>

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For families with young children, the antimicrobial property of copper tubes effectively prevents bacteria growth in enclosed spaces, making it an essential feature for upgrading home appliances to meet the heightened focus on health and hygiene in a post-pandemic world.

On the environmental front, copper's 100 percent recyclability helps form a perfect circular economy cycle. Even after many years of use, copper can be regenerated through pyrometallurgical or hydrometallurgical refining processes without losing its quality. By recycling waste copper, the need for new copper mining is significantly reduced, valuable natural resources are conserved, the lifespan of copper mines is extended, and the long-term, stable supply of copper resources is ensured.

Regarding energy savings, recycling copper uses far less energy than mining and refining new copper. Copper recycling can save as much as 85 percent of the energy needed compared to primary production. Direct utilization and electrorefining save over 80 percent and around 50 percent, respectively,

reducing production costs and minimizing reliance on fossil fuels, thus contributing to a low-carbon economy.

Copper recycling also plays a crucial role in significantly reducing waste generation and environmental pollution. It helps to mitigate the negative impact of discarded copper on soil and water resources. Compared to mining new copper, copper recycling produces much fewer greenhouse gases. Recycling one ton of copper can reduce carbon dioxide emissions by approximately 2.1 tons, contributing to the global effort to combat climate change.

Midea's R290 Refrigerant Technology: The Synergistic Evolution of Copper and New Refrigerants

1. R290 Refrigerant: The "Natural Choice" for the Low-Carbon Era

On the other side of the "Copper Inside" booth, Midea's Grade 1 Energy Efficiency split inverter wall-mounted air conditioner with R290 refrigerant vividly showcased the synergistic innovation between copper technology and new eco-friendly refrigerants, underscoring copper's vital role in supporting the use of R290 refrigerant in air

conditioning systems.

The system's small-diameter copper tube heat exchanger is crucial in this breakthrough green technology. As a natural hydrocarbon refrigerant, R290 (propane) offers revolutionary environmental benefits: it has an Ozone Depletion Potential (ODP) of zero and a Global Warming Potential (GWP) of just 3. Traditional refrigerants have much higher GWPs: R410A has a GWP of 2088 and R32 has a GWP of 675. Air conditioners using R290 refrigerants have an almost negligible impact on global warming, which aligns perfectly with the goals outlined in the Montreal Protocol's Kigali Amendment for eliminating Hydrofluorocarbons (HFCs) and China's "dual carbon" targets.

In the global context of advocating for low-carbon, sustainable living, these advantages of R290 refrigerant are pivotal in reducing the environmental footprint of air conditioning products. However, to fully leverage the potential of R290 refrigerant, stable operation is essential, and this is where copper's role becomes critical.

The use of R290 faces two significant challenges: first, its flammability, as propane has an explosion limit of 2.1%-9.5% in air, requiring strict control over the refrigerant charge; second, the compatibility of materials with the refrigerant, as hydrocarbons can chemically react with certain metals, creating potential safety risks. Here again, copper demonstrates its advantages. Copper offers exceptional chemical stability with R290. Furthermore, small-diameter copper tube technology reduces the refrigerant charge, overcoming safety and efficiency bottlenecks.

2. Small-Diameter Copper Tube Heat Exchanger Technology: The



"Key" to Solving the Paradox of Safety and Efficiency

Midea's research and development in small-diameter copper tube (SDCT) heat exchangers features high-efficiency inner-grooved copper tubes with an outer diameter of just 5 mm. Although this design change may seem insignificant initially, it embodies profound innovations in materials science and fluid dynamics. SDCT heat exchanger technology uses high-efficiency inner-grooved copper tubes with 5 mm outer-diameter. Combined with meticulously optimized fins and flow path designs, SDCT designs ensure that heat exchange efficiency is not compromised while significantly reducing refrigerant usage.

Midea has balanced technological advancement and environmental value by integrating this SDCT heat exchanger technology with R290 (propane) refrigerant. The design of the small-diameter copper tube reduces the use of copper material, leading to reduced costs and lighter equipment while simultaneously decreasing the overall system volume. This innovation allows the refrigerant charge to be controlled within 300 grams, significantly improving the safety of this flammable refrigerant and meeting the stringent international standards on refrigerant charge limits. The smaller diameter also leads to higher refrigerant flow speeds, enhancing the turbulence effect and improving the heat transfer coefficient by up to 15 percent.

Given R290's outstanding thermodynamic properties (its evaporation latent heat is 20 percent higher than that of R410A), this technology can reduce compressor power consumption, improve energy efficiency, and

lower electricity consumption while reducing indirect carbon emissions. The overall energy efficiency ratio (APF) can reach as high as 5.2, exceeding the national level Grade 1 energy efficiency standard (5.0).

With such efficiency of energy utilization, air conditioning energy consumption is naturally reduced, lowering operational costs for users. More significantly, on a global scale, the widespread adoption of such highly efficient and energy-saving air conditioners will contribute immensely to society's low-carbon objectives, helping address global challenges such as climate change and other pressing environmental issues.

3. From Technological Innovation to Industrial Ecology: The "Hidden Value" of Copper

Midea is one of the pioneers in

researching and applying R290 refrigerant in air conditioners. Since 2008, Midea has been strategically investing in developing R290-related technologies. In 2011, with financial support from the United Nations Multilateral Fund, Midea completed the first-ever industry transformation of a production line for R290 compressors and developed the first R290 fixed-speed air conditioning unit. In 2013, Midea's R290 air conditioning compressor became the first of its kind to be mass-produced in the industry, and the R290 air conditioners developed by Midea received the first-ever 3C certification in the industry. In 2015, Midea's R290 mobile air conditioners successfully entered the European market, marking a significant step forward in global expansion. In 2016, Midea



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established the world's first R290 application demonstration base, further solidifying its leadership in this field. In 2017, Midea received the prestigious "Outstanding Contribution Award for 30 Years of the Montreal Protocol" from the United Nations.

In 2018, Midea's R290 products earned the global first "German Blue Angel Certification" in the air conditioning industry, with R290's key technologies recognized as internationally advanced. In 2019, Midea was awarded the "Low Carbon Environmental Protection Leadership Award" by the United Nations Environment Programme and other prominent organizations. In 2020, the United Nations Industrial Development Organization presented Midea with the "Outstanding Contribution Award for Energy Saving and Environmental Protection." In 2021, Midea received the "German Blue Angel Certification" once again.

Over the past 14 years, Midea has steadily moved from fixed-speed air conditioners to variable-frequency air conditioners, and from split air conditioners to integrated air conditioners. It has expanded its presence from the domestic market to the global stage. Midea's journey demonstrates its unwavering commitment to establishing a strong industry position and voice in R290 technology.

Midea's experience has shown that the value of copper lies not just in the material itself but also in its optimal synergy with the overall system. The low GWP (Global Warming Potential) characteristics of R290 refrigerant demand compatible hardware, and copper's natural resistance to corrosion, excellent thermal conductivity, and adaptability to processing make it the perfect material to support this innovative technology. This combination of "material-technology standards" has fostered a shift

in the air conditioning industry, moving from upgrades in individual components to system-level innovations.

The SDCT heat exchanger design has made it possible to reduce the size of heat exchangers, facilitating the development of smaller and lighter air conditioners and reducing the refrigerant charge of R290, decreasing the flammability and improving the system's safety. This, in turn, has resulted in a significant reduction in carbon emissions associated with transportation and installation.

Empowering the Industry with Copper: From Individual Products to Full Industrial Chain Transformation

In other areas of the AWE2025 exhibition, the role of copper is evident across various applications: oxygen-free copper liners in water heaters, copper evaporators in refrigerators and copper coil motors



in washing machines are just a few examples, which reinforce a widely shared understanding: Copper is rapidly becoming the “universal language” for decarbonization in the home appliance industry. Statistics show that global copper usage in the home appliance sector has grown from 1.5 million tons in 2010 to 2.3 million tons by 2024, with an average annual growth rate of 4.5 percent. This growth rate far outpaces that of steel (1.2%) and aluminum (2.8%).

This rapid growth is driven by the irreplaceable role of copper in several key areas: In heat pump technology, copper tube heat exchangers are 30 percent more efficient than their steel counterparts, significantly boosting the performance of air-source water heaters with a 300 percent energy efficiency ratio. In variable-frequency motors, copper windings have a 60 percent higher electrical conductivity than aluminum, reducing electromagnetic losses and improving motor efficiency by more than 5 percent. In the realm of 5G smart appliances, copper’s exceptional electromagnetic shielding properties ensure stable signal transmission and prevent interference that could arise from plastic casings, ensuring uninterrupted performance.

Envisioning the Future: How Copper Continues Its “Green Metal” Legacy

The “Copper Inside” booth at AWE 2025 is not only a showcase of technological achievements but also a rethinking of the “value of materials,” fostering a deep dialogue on sustainable development. As AI and the Internet of Things continue to reshape the home appliance

industry, copper’s “ancient yet ever-new” properties exemplify how foundational materials can drive industrial transformation. When the high-quality products such as Casarte’s 100 percent Full Copper Refrigerant Tube air conditioners safeguard performance and Midea’s R290 refrigerant-based variable-frequency split air conditioners lower carbon footprints, copper has evolved beyond being just a material: It is becoming a key connector between technological breakthroughs, consumer upgrades, and environmental protection.

As the “Copper Inside” coalition grows and deeper collaboration within the industrial chain unfolds, copper materials are poised to write a low-carbon success story across even broader sectors. Achieving this vision will require more than just technological investments from companies. It will require active participation from policymakers, industry organizations, and consumers. When every full-copper appliance becomes a “green living” micro-unit, and every meter of copper tubing serves as a neuron in a low-carbon network, we will be witnessing an industry-wide ecological reconstruction powered by a materials revolution—one in which copper, in its “green metal” form, leads the way.

As the countdown to carbon neutrality continues, the story of copper is far from over. It serves as a reminder that a genuinely low-carbon revolution starts with meticulous attention to every detail and exploration of every potential. When technology and nature find harmony in copper materials, we will witness more efficient home appliances and pave the way for a sustainable future.

Copper will continue to create a more comfortable and sustainable lifestyle for global users, and the International Copper Association will continue to play an essential role in certification, promotion, and guiding the development direction of the industry in this process.



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