SUSTAINABILITY, RELIABILITY & EFFICIENCY

A Look into Today's Trends and Opportunities for HVAC

Diving into 2022 and beyond, government and industry leaders are focused on identifying ways to address energy and clean air issues in the face of major environmental, healthy living and consumer trends that drive how we all live and operate. One area of focus: HVAC.

HVAC systems provide heat, ventilation, and air conditioning for both residential and commercial buildings. These systems filter and clean indoor air to keep people healthy, comfortable and maintain optimal humidity levels. With a focus on energy-efficient and clean air advancements, HVAC capabilities are effectively attempting to address climate change and decarbonization concerns while also delivering the kinds of safe, healthy, and comfortable-living solutions required from a growing and increasingly urbanized population.

Residential
Houses, small stores and restaurants

Commercial
Office buildings, hotels, shopping malls, warehouses and medical establishments

Energy-efficient system advancements are fueling the significant growth of the global HVAC market. With recorded sales of approximately $241 billion in 2020, HVAC is projected to reach more than $300 billion by 2026. [1]

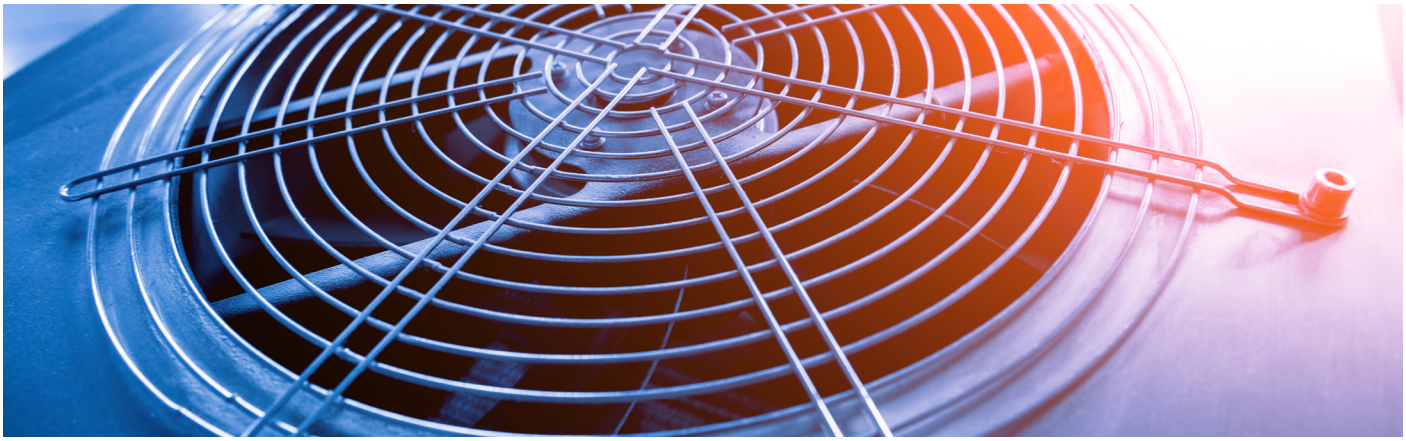
We at TE Connectivity (TE), a world leader in connectivity and sensor technology, have taken a closer look at the HVAC market and are sharing our insights to help manufacturers capitalize on the opportunity for innovation and market share gain. Engineers need to be aware of the myriad of global issues and trends driving HVAC systems growth, and the design and technology challenges that must be considered.

Market Shifts and Trends

We are all living amidst unprecedented change, resulting from a cross-current of environmental and public health issues that are impacting our world and heightened focus on healthy, energy-efficient solutions. As the adoption of energy-efficient systems that reduce costs and power wastage becomes more prominent around the world, here's a closer look at the underlying changes that are driving HVAC growth now and will continue to do so, into the foreseeable future.

Net Zero and Decarbonization

The march to net zero is an unavoidable reality in the continuing fight against climate change and presents a direct challenge to the buildings and construction sectors. A 2019 report from the International Energy Agency (IEA) indicated that these two sectors combined were responsible for more than 30% of global energy consumption and nearly 40% of carbon emissions.



In 2015, the Paris Agreement was signed by 196 countries to limit global warming and reduce greenhouse gas emissions in order to achieve a climate neutral world by mid-century. This has helped to usher in new government policies and grants to improve energy-efficiency and support clean energy innovations. Paving the way for investments in HVAC technologies around the world.

- In the **Asia Pacific** region, Australia has instituted minimum energy performance standards while the Indian Bureau of Energy Efficiency and Labelling Standards is looking for manufacturers to actively adopt more advanced cooling technologies. The Chinese government is promoting the efficient use of energy, establishing minimum allowable values for energy efficiency and related grades for room air conditioners. The new standard, GB 21455-2019, is not only the strictest standard introduced to date in the Chinese market but is considered among the most stringent on an international basis, as well [2].

- In **Europe**, countries across the continent are initiating net zero strategies based on policies recommended by the International Energy Agency. For example, the United Kingdom (UK) and France have massive regulatory frameworks in place and binding targets for the building sector. In the UK, achieving net zero includes a plan to install 600,000 heat pumps per year by 2028. [3] Not only has this expanded UK manufacturing but the government is investing an additional £60 million into heat pump innovation. In addition, low-carbon heating systems will be required in all new homes built after 2025, replacing gas boilers [4].

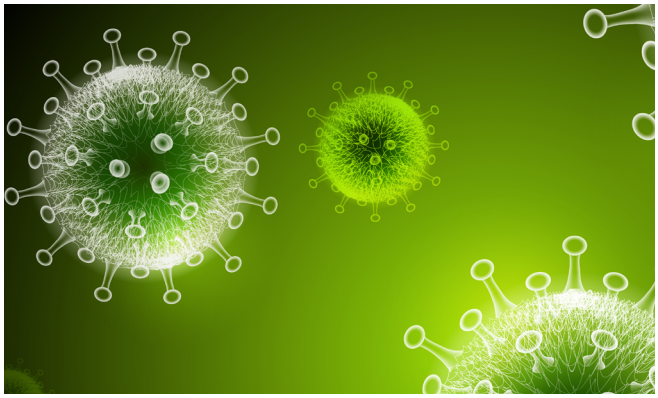
- In **North America**, the U.S. and Canadian governments are issuing grants and making investments in energy-efficient technology. In addition, local government incentives and personal tax credits in the U.S., are encouraging energy-saving home improvements to help offset costs. Policy changes are also going into effect. Minimum Energy Performance Standards (MEPS) will be required for residential central air conditioners and heat pumps. Products installed as part of a home's central heating and cooling system and manufactured after January 1, 2023 will need to meet minimum Seasonal Energy Efficiency Ratios (SEER) and Heating Seasonal Performance Factors (HSPF) [5].

Beyond government programs and regulatory pressures to construct net zero buildings, the private sector – whether in response to consumer demands or shareholder activism – has also embraced the need for net zero commitments. Companies are pledging net zero emission targets and taking a harder look at their overall operations, including the energy efficiency of the buildings in which they work. Together, these forces are steering construction companies to look towards HVAC companies for energy-efficient or low CO_2 emitting systems that meet net zero thresholds.

With 60-70% of the global production of heating and cooling equipment coming from companies that have announced net zero emissions targets, 6 the HVAC industry is well-positioned to drive energy efficiency, reduce greenhouse gas emissions and improve indoor air quality.

Covid-19

Since its emergence in 2020, the Covid-19 pandemic has changed the way in which the world operates. Among the fragilities it has exposed is the direct correlation between HVAC systems and the spread of germs, dramatically changing the landscape for indoor environment control. Reports have claimed that HVAC systems are a probable point of contact to spread the virus by recirculating contaminated air. This has led to a heightened increase in the inspection, testing, surface and air sampling, cleaning, and disinfecting of HVAC air conveyance systems and associated ductwork.



Increased awareness on indoor air quality has also led to new standards that require better air filtering and ventilation, as well as air quality monitoring. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has set new guidelines for filtration rates to maintain good indoor air quality, while the Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA) has put forth recommendations on how to make HVAC units safer.

Infrastructure Needs, Population Growth and Changing Lifestyles

In addition to being driven by net zero goals and Covid-19, demand for HVAC systems is increasing due to infrastructure needs that support residential and commercial growth and changing personal lifestyle preferences.

- In the emerging Asia Pacific and Middle East regions, commercial construction projects that require infrastructure commitments are the major drivers for the global commercial HVAC market – particularly in developing countries such as China and India. On the residential development front, a growing population is also leading to new HVAC installations across the region, with high demand for energy-efficient air conditioners that can offset hot and extreme weather conditions.
- Conversely, in both Europe and North America, HVAC growth is mainly being driven by the maintenance and replacement of services. However, in places like the U.S, a rising average of construction spending, rapid urbanization, growth in disposable income, and an increased focus on smart homes have all accelerated the installation of HVAC systems.

HVAC Market: A Look at Global Growth Projections

The global HVAC market comprised both the residential and commercials sectors. Estimated to reach $270 billion in sales between 2025-2030, it has a projected CAGR of 5.3% over the next 4-9 years.

Much of this growth has been led by the **residential** segment, which accounted for more than 40% of sales in 2021. However, the **commercial** HVAC market is poised for growth, estimated to reach **$29.4 billion by 2026** and reflecting a 6% CAGR between 2020-2026. By geography:

- The **Asia Pacific** HVAC market is projected to reach a value of **$70.7 billion by 2024**. China is expected to be the largest market, as it was the largest contributor to the HVAC market in 2021 with a more than 45% revenue share owing to the rise in population, urbanization and surge in consumers' disposable income.
- The **European** HVAC market is expected to reach **$78 billion by 2025**. This is significant growth even with a lack of uniformity in demand from countries across the continent, a dependence on fiscal stimulus, the containment of Covid-19 spread, and the recovery of the construction industry.
- **North America's** HVAC market was valued at $32 billion in sales in 2020 and is expected to reach **$43.2 billion by 2026**. This reflects a CAGR of 4.7% over the 2021-2026 period.

HVAC Overview

Residential Market

Applications
- Cooling
- Heating
- Humidity
- Ventilation

Types of Residential HVAC Systems
- Central Air Conditioner
- Ductless Mini-Split
- Window Air Conditioner
- Portable Air Conditioner
- Floor Mounted Air Conditioner
- Hybrid / Dual Fuel Air Conditioner
- Through the wall Air Conditioner
- Smart Air Conditioner
- Geothermal Air Conditioner

Subsystems of Residential HVAC Systems
- Furnace / Air handler
- Evaporator Coil
- Condenser
- Supply Air Ducting
- Return Air
- Adaptions
- Supply Air Runs
- Return Air Runs
- Flue / Chimney Piping

Commercial Market

Applications
- Cooling
- Heating
- Ventilation
- Filtering
- Dehumidification
- Air-purification

Types of Commercial HVAC Systems
- Single Split System
- Multi-Split System Air Conditioning
- Variable Refrigerant Flow (VRF) and Variable Refrigerant Volume (VRV)

Subsystems of Commercial HVAC Systems
- Air Conditioner
- Compressor
- Condenser
- Thermal Expansion Valve
- Air Handler (including Evaporator Coil and Blower)
- Terminal Units
- Chiller

Design Challenges

With the HVAC industry primed for both residential and commercial growth, HVAC designers are being tasked to create highly energy-efficient systems. Designs are also impacted by a number of considerations and challenges.

- **Harsh environments:** HVAC systems need designs to withstand harsh conditions in both hot and cold climates by taking into account dust and debris limiting condensation and humidity and reducing corrosion. For example, water ingress causes deterioration of exterior wall assemblies, requiring HVAC designs to accommodate more airtight and insulated wall and window assemblies. Limited floor space, a large glazing area and ceiling height, and opaque window coverings that offer privacy but reduce the amount of interior heat, are factors that must be considered in addressing condensation concerns. In addition, HVAC systems need to control indoor humidity in both heating and cooling mode to prevent moisture that causes damage to building materials and components
- **Maintenance:** Ongoing maintenance is a critical component for the effective use and long-term value of HVAC systems in both residential and particularly, commercial settings. As a result, designers must build systems that offer relative ease in maintenance, repair, as well as retrofitting
- **HVAC upgrades:** Designers need to pay close attention to controlled ventilation, dehumidification, and filtration within their HVAC designs as these are key areas where facility managers are focusing on upgrades. ASHRAE and REHVA guidelines have given rise to HVAC upgrades that include:
    - Replacing fixed-speed with variable-speed fan motors to enhance the control of airflow and allow for a minimum setting that produces lower speed airflow
    - Introducing sophisticated airflow-control systems, such as those that are sensitive to pressure, in allowing for smoother adjustment of airflows
    - Installing high-performance air-purification systems to reduce dirty indoor air, which can be rife with recirculating allergens, bacteria, and viruses
- **Smart home compatibility:** A well-designed IoT-enabled HVAC system must allow for seamless data accumulation, filtering, and sharing in smart home applications. Along with these analytics, the systems should be enabled with preventive maintenance and continuous optimization. Connected HVAC platforms should also provide users with direct access to power consumption and CO_2 emissions stats
- **Seamless technologies/data reliability:** System designs require interoperability and inter-usability among its various parts to maximize functionalities and overall system efficiencies, as and ease the integration of component parts into a larger system. Data reliability is also key to the HVAC unit in producing better operational results. Data provided by air quality sensors not only can unlock the combined benefits of greater efficiency and better indoor air quality through HVAC optimizations, but also can help earn building certifications and boost occupant wellness. In addition, product concepts for connected HVAC systems should consider data reliability in preventing and dealing with lost messages. If expected data packets fail to arrive, the design should assume conservative default values, so that people and technology are protected from damage, and there is no loss of comfort to the user
- **Ventilation to minimize pollutants/Covid-19:** HVAC systems must work with other air quality and purification systems to provide effective ventilation and minimize the spread of viruses, such as Covid-19, and other sources of indoor pollution. Epidemiologic evidence has put pressure on HVAC designers to maintain Indoor Air Quality (IAQ) as science has demonstrated a clear association between exposure to damp indoor environments and adverse health effects. Prolonged damp conditions can lead to growth of molds, bacteria, and insect pests in HVAC systems – an issue that must be eliminated to avoid "sick building syndrome"
- **Cost-Savings:** Apart from these listed challenges, HVAC equipment manufacturers and design engineers must adhere to regulatory standards and energy-efficiency labels while keeping costs in-check. The value-add that any advanced feature provides should offset all other associated costs

Testing Capabilities

Testing is also an important component of any system design. For HVAC, there are three primary testing areas to be considered:

- **Environment tests:** HVAC systems must be able to withstand thermal shock and condensation and humidity, as well as reduce corrosion. Issues to evaluate include temperature cycling; salt spray; mixed-flow gas; dust/ waterproofing; glow wire testing (GWT), hot-wire ignition (HWI) and needle flame testing; as well as Highly Accelerated Life Test (HALT) and Highly Accelerated Stress Screen (HASS) testing
- **Electrical tests:** The impact of high current and temperature rise in HVAC poses challenges to components. Testing should evaluate low level contact resistance; dielectric withstanding voltage; current carrying capacity; temperature rise; and electromagnetic compatibility (EMC)
- **Mechanical tests:** Long-term, high-intensity operations in harsh environments place high demands on durability within HVAC systems. Testing should evaluate sinusoidal/random vibrations with temperature and humidity; and normal force and low-level contact resistance (LLCR)

How TE Connectivity Leads with Quality Engineering Solutions

TE Connectivity (TE) offers an extensive portfolio of products to meet HVAC system design requirements, with a particular emphasis on producing products that meet the demands of harsh outdoor environments and miniaturization. Our sealed portfolio of power and signal connectors, terminals and splices, sensors, heat shrink tubing; and standard and customized antennas covers a broad array of connectivity needs and provides design engineers and manufacturers with the products required to meet the emerging demands of HVAC systems. In addition, our product portfolios are designed with extensive engineering expertise to provide customers with high-performing design solutions that meet a range of connectivity challenges and industry requirements.

Our portfolio of products focuses on key Design Solutions:

- Magnet Wire Solutions- (IDC) Technology
- Sealing and insulation offerings
- Miniaturization
- Extra locking mechanisms - TPAs and CPAs
- High Current Offerings

- **Connectors**: Our connectors are designed to reduce application size while managing power and signal usage and enabling increased performance in the harshest conditions. We offer IP67 rated sealing options and ergonomics-friendly connectors that are glow wire tested (GWT) and come with optional terminal position assurance (TPA) and connector position assurance (CPA) for extra protection, with operating temperatures up to 110°C
- **Sensors**: We offer a broad portfolio of sensors for smart HVAC systems to integrate with a building's automation system and collect information about building conditions throughout. These sensors can also be used to integrate weather predictions and energy usage trends to minimize power consumption and optimize temperature regulation. As per an IEA report, smart controls (sensors) and connected devices are expected to save 230 EJ (about 63,888,888 GWh) in cumulative energy savings by 2040 and help lower buildings' energy consumption by as much as 10% globally
- **Antennas**: With the ability to maintain high-quality transmissions in wireless devices, our broad range of standard and custom antennas can transmit reliably using 5G, LTE, Cat-M, NB-IoT, GNSS, Wi-Fi, Bluetooth, V2X, ISM and LPWAN bands and more. With antenna design and manufacturing facilities worldwide, we offer testing capabilities in near- and far-field patterns, scattering parameters, specific absorption rate (SAR), vibration, humidity, temperature shock, salt fog, throughput, and acoustics. Since the choice of antenna can be critical to system reliability and function, and certainly required for increasing IoT applications, they should be considered at the onset of the HVAC concept and design process
- **Heat Shrink Tubing:** Designed to perform in the most demanding conditions, TE's heat shrink tubing portfolio comes in a wide range of single-wall, dual-wall and specialty options that seal, protect, and insulate components that require the most protection. This addresses the critical need for many HVAC systems that must be resistant to high operating temperatures, water, and other destructive elements
- **Relays or Switching Solutions**: Our switching devices are designed and manufactured to be used in harsh environments anywhere. With a focus on safety-critical applications, solutions perform to specification for shock, vibration, temperature, and altitude. This includes contactors, relays, switches, and circuit breakers that offer cost-effective, reliable performance to enhance productivity

TE is a global industrial technology leader with a footprint that includes operations in virtually every region of the world. As a design partner, we innovate alongside our customers and clients, sharing our expertise gained from extensive cross-industry, hands on experience. We understand how connectors, sensors, antennas, tubing, and other components work together to deliver reliable, steady performance and use this knowledge to optimize performance in creating more energy-efficient HVAC system designs, even in the harshest environments.

Finding ways to solve customer design challenges while maintaining or increasing reliability and performance are the standards by which TE distinguishes our work and approach. These also reflect some of the ways in which TE lives up to its purpose in creating a safer, sustainable, productive, connected and, increasingly more efficient future.

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