

# **Triboelectric Nanogenerator Market - Forecasts from 2020 to 2025**

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## **Abstracts**

The triboelectric nanogenerator market are expected to grow at a compound annual growth rate of 48.55% over the forecast period to reach a market size of US\$134.119 million in 2025 from US\$18.543 million in 2019.

Triboelectric Nanogenerator works upon the base principle which combines triboelectric charging and electrostatic induction. The process initiates by the formation of two materials in contact with each other, which then undergo chemical reaction on the surface to activate the charges forming electrochemical potential and thus generating triboelectric charges. The nanogenerators have basic modes which are vertical contact separation, lateral sliding, single electrode, and freestanding mode. The self-powered powered systems of Triboelectric nanogenerators are based upon the modes which are used across the industry verticals such as Mechanical Engineering, Consumer and Industrial electronics, textiles, and medical industry. Triboelectric Nanogenerators have greatly been used to bring down the size of automated machinery to optimize the space and its operational efficiency which can be produced at a massive scale to ensure scalability and replicability.

The market has been classified based on Operation Modes which are Vertical contact separation mode, In-plane sliding mode, and Single-electrode. By applications, the market has been classified as consumer electronics, healthcare, aerospace and defense, and others. The geographical distribution of the market has been done into North America, South America, Europe, Middle East and Africa, and the Asia Pacific.

Countries such as India, China are the cost-effective manufacturers of products using Triboelectric nanogenerators with limited knowledge and research and development resources. Whereas the US, Japan, Germany can be regarded as nations with world-

class research and development with limited manufacturing resources. So, there is a frequent contract manufacturing and licensing to the countries like India, China, Vietnam, and South Korea was given reasonable quality with relatively cheap labor and production cost.

In the wake of the Covid-19 pandemic, there is increasing dependence on clean and sustainable sources of energy which is scalable and easy to replicate to ensure last-mile connectivity. Nanotechnology can play a significant role in connecting people and making machinery for manufacturing and ICT to be available to all to ensure smooth working. However, the halt in the manufacturing activities across several industrial sectors due to disruption in the supply chains caused by the outbreak may restrict the market growth to some extent, particularly during the short run.

Advancement of utility electronics with space, cost, and installation efficient metrics

The application of nanotechnology can be seen in the everyday gadgets and widgets used daily in households and industries. With the change in the market demographics, it is witnessed that consumer electronics have undergone massive transformation featuring minimalistic designs with superior quality which can be regarded as the prime application of Triboelectric nanogenerators. The minimalistic products are currently high priced with justifications to worth in terms of its space, cost, and consumer savvy self-installation product kits requiring minimal efforts from the customers end. Apart from electronics, Triboelectric nanogenerators (TENG) have brought under the use of Dielectric elastomers, microfluidic-based mini vehicles, liquid lenses, stimulated microplasma, micro actuators, electro adhesion for coatings and bonds, electrospinning and mass spectrometer applications. Which is further propelling the business growth opportunities for the players of the market.

With the revolutionizing advancement of TENG nanotechnology, there has been emergence of self-powered high voltage industrial applications. Unequivocally with scope of improvement such as improving the technology in terms of electrical output and reliability with limited breakdown effect, efficient energy management circuits, changing wired transmission to wireless, and compatibility with inline robotics,

Need for integrated durable Triboelectric Nanogenerator in consumable electronics

Triboelectric generators have primarily been into use to miniaturize physical electronic devices such as computing devices, tablets, etc. without compromising upon the utility of the product in terms of effectiveness and efficiency. There has been constant need

under electrical engineering domain to make the devices and its chipset of fiber or fabric-based Triboelectric Nanogenerator to be of durability as when miniaturized it gets complicated and weak to withstand much of the external strength to be used for a long duration. The pandemic has shown the growth in the sales of electronic and computing devices which are now classified as a necessity, nanogenerators fabrics need to be updated and manufactured with cost-effective methods so that the benefit can be shifted to the consumers and be available at affordable prices in the countries such as India, Bangladesh.

## Regional Analysis

China, the USA, India stands at the top three leading nanotechnology countries followed by South Korea, Germany, and Japan. China holds a significant share in mass manufacturing with the least cost achieving economies of scale whereas Japan, and the USA has resources for research and development of cutting-edge nanotechnologies. Countries such as India has a great resource of engineering scholars and research institutions as Indian Institute of Technology and cost-effective manufacturing facilities giving the best alternatives to investors against China. China has taken the brunt over the electronics and engineering trade due to series of US-China trade wars and conspiracies based on initiating covid-19 leading to boycott of Chinese origin, which has benefitted countries such as India, Vietnam, South Korea, Japan, and Germany.

## Segmentation

### By Operation Modes

Vertical contact separation mode

In-plane sliding mode

Single-electrode

### By Applications

Consumer Electronics

Healthcare

Aerospace and Defense

Others

By Geography

Americas

Europe Middle East and Africa

Asia Pacific

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