In the new global economy, energy and the environment have become two of the most central issues in the 21st century. The civilization of mankind has resulted in great success in industrial development and given rise to the predicted depletion of non-renewable energy sources such as fossil fuels and irreversible climate change. Over the decades, the total global energy consumption has increased dramatically and ultimately is anticipated to reach a striking value of 778 Etta joule (18 million tons of oil equivalent) by 2035. Correspondingly, research on alternative energy technologies becomes the key point for a sustainable future and therefore has been introduced as one of the main goals of the European Green Deal as well as adopted as the development strategy of the Silesian Voivodeship of Poland under the concept of Green Economy and Power Engineering.

Although solar energy, wind energy, and biomass energy production are the most concentrated topics among renewable energy sources, the demand for the proliferation of self-powered, autonomous electronic devices in a variety of applications covering the Internet of things, wireless sensors, security/surveillance increase the requirement of portable/wearable and lightweight power supplies. However, traditional energy sources are not only insufficient to fulfill this expectation yet since they are also dependent on external sources (such as sunlight, wind, etc.) making these systems indirectly disadvantageous. Nevertheless, if universally available mechanical energy and dissipated work are used properly and converted efficiently into electrical energy through a viable and low-cost system, it will be able to meet the electricity needs in many areas such as mobile compact devices. In this context, triboelectric nanogenerators (TENGs) can be considered promising next-generation systems for fulfilling the discussed energy gap.

TENGs are unique devices with high energy generation potential to convert ambient mechanical energy produced by human actions such as stepping, breathing, pulse, and arm motions into electrical energy with a single movement. In addition to being cost-effective and practical to be produced as a device structure, they are zero-emission systems making the monotony of human daily life valuable by converting dissipated work into electrical energy. Until now, works on TENGs have focused primarily on optimizing systems and designing circuits or exploring possible applications. From a methodologic perspective, major obstacles here are not only related to material-regulated efficient triboelectric charge generation but also associated with the ineffective extraction of generated charges due to the charge screening that shrinks the triboelectric potential between tribo-charges in the material and the surface charges in the electrode. This phenomenon is treated as the actual limitation of TENG studies leading to considerably lower output performance than theoretically calculated. Therefore, it is clear that more innovative and realistic strategies are needed to address these issues for developing eco-friendly TENG devices with increased output performance.

The approaches in the literature have mentioned the utilization of physical techniques to overcome this weakness such as increasing the specific surface area, modification of relative permittivity, and functionalizing the triboelectric material surface to prevent performance degradation. However, such approaches have been quite limited to completely overcoming the material intrinsic charge production and unintended loss of charge extraction. Therefore, the Nano-Charge project is designed to benefit from the state-of-the-art advances of material science and the comprehensive framework of device engineering to deal with the aforementioned problems and to come up with innovative strategies to be applied from small-scale device fabrication to large-scale TENG module production. In this project, we will focus on the application of electroactive structures with different electrochemical properties to efficiently regulate intrinsic charge separation. Herein, the doping of proposed structures to commercial materials is deliberately preferred as bulk-scale production of durable dielectric layers requires the feasible process of easily accessible materials specifically for rough operating conditions. However, commercial materials do not always fulfill the desired electrical properties, though many of them are proposed as high tribopotential substances in the triboelectric chart. This situation is regarded as one of the main obstacles in front of large-scale fabrication of new-generation energy devices. Overall, the Nano-Charge project is anticipated to provide comprehensive pathways for evaluating the contribution of a diverse group of materials to current TENG studies and is expected to substantially enhance our systematic understanding of their challenges, opportunities, and participation in renewable energy studies.