

Since the launch of the first commercial power plant, the equipment used to generate and distribute electricity has undergone substantial changes and improvements; nonetheless, fossil fuels remain the main source of primary energy. In the 21st century, the problems of atmospheric pollution and the finite nature of fossil-fuel reserves have come into sharper focus. Consequently, many countries especially highly developed ones have taken steps to curb emissions of harmful substances. A cornerstone of this strategy is to greatly increase the share of renewable energy sources (RES) in electricity production. Yet a rising share of RES in the energy mix brings new challenges and problems. Among renewable-based technologies, photovoltaics and wind turbines are the most popular. Unfortunately, their output is inherently intermittent and weather-dependent, so peak generation often does not coincide with peak demand. This complicates power-system balancing and forces the development of energy-storage technologies, but today's storage solutions may struggle to keep up with the rapidly expanding RES capacity. As a result, the drive to cut emissions and match generation to a dynamic energy market is motivating scientists worldwide to seek new solutions that can meet these requirements and ensure grid stability.

One promising technology that could play an important role in modern energy systems is the solid oxide cell (SOC). Its key advantages are high energy-conversion efficiency, low emissions, and the ability to operate in cogeneration setups. SOCs can work in fuel-cell mode (SOFC), converting hydrogen-based fuels directly into electricity via electrochemical reactions, or in electrolyze mode (SOEC), producing hydrogen by steam electrolysis using externally supplied electricity. The core idea is to generate hydrogen or other synthetic fuels when RES output is in surplus and then use that fuel to produce electricity during periods of high demand. These devices are not without drawbacks, however. The main barrier to widespread SOC adoption is their high operating temperature (typically above 800 °C), which accelerates the physico-chemical degradation of components, shortens lifetime, causes compatibility issues among elements, and lengthens start-up time. Lowering the operating temperature with today's materials sharply reduces performance, so the key challenge is to find materials that can maintain high performance at reduced temperatures. To tackle this, researchers are developing various electrode-manufacturing approaches aimed at boosting their properties. Unlike the electrolyte, which must conduct only ions, electrodes need mixed ionic-electronic conductivity. In recent years, perovskite-structured oxides have become leading candidates: they conduct electricity well and their properties can be "tuned" by trace elemental doping. Another innovative approach is to shift the material morphology from traditional powder form to nanofibrous structures. Nanofibers have exceptional characteristics, very high surface-area-to-volume ratios, high porosity, and excellent mechanical properties that can markedly enhance electrode electrochemical performance.

Within this project, the material  $\text{Sr}_2\text{Fe}_{1.5}\text{Mo}_{0.5}\text{O}_{6-\delta}$ , a double-perovskite oxide well known as an SOFC electrode material, will be studied. For the first time it will be synthesized as nanofibers and additionally doped with nickel so that nickel nanoparticles form on the fiber surfaces during operation in hydrogen. A nanofibrous composite containing an ionic conductor is also planned, aiming to further boost performance. Expected outcomes include the development of new, more efficient electrode materials with enhanced durability, which could help commercialize fuel cells operating at lower temperatures. The project may also provide fundamental insights into how nanofibrous morphology affects electrochemical processes and material stability under cyclic operation. These findings could have wide applications in advancing energy technologies, contributing to the construction of more efficient and environmentally friendly electricity-generation systems.