Aim of the project: In recent decades, rapid societal and technological development increased energy demand and substantially depleted fossil fuel reserves, caused pollution and overall disruption of the global climate. To prevent depreciation of living standards, it is time to focus on safe, efficient and inexpensive renewable energy solutions. It is justified to say that the performance of thermal equipment (for energy production, transport, and storage) using common heat transfer fluids (water, glycols, oils, etc.), has reached its operational limit. It is more important than ever to turn the gaze of researchers from applied sciences i.e., development of a new kind of heat exchangers and systems, back to the basic research including properties and thermal performance of high efficiency working fluids. Nanofluids (i.e., fluids enhanced with nanoparticles) appear to be the most promising solution. Despite consequences of using solid particles (higher pressure drop, sedimentation, long-term instability, etc.), nanofluids offer impressive thermal properties in comparison to conventional fluids. Ferromagnetic nanofluids (FNFs) seem to be especially interesting. They contain ferromagnetic nanoparticles that can be controlled with magnetic fields. Experimental and numerical findings confirmed possibility of heat transfer enhancement if the magnetic field has the same orientation as the heat flux. Similar reasoning applies to the gravity, which affects solid nanoparticles in the fluid. In theory, these effects allow switchable heat and mass transfer capabilities.

The proposed project concentrates on forces influencing the FNF pipe flow (viscosity, buoyancy, gravity and magnetic field). **The aim is to study heat and mass flow processes during the laminar flow of FNF with particular focus on the influence of magnetic field (its direction and strength) and direction of gravity force on convective heat transfer process.** To reach the goal, the magnetic field and the direction of gravity (inclination of the pipe) will be used to influence heat and mass transfer, providing insight into operation of FNF-based convective heat exchangers.

Research carried out in the project: This project will focus on the interaction of viscosity, inertia, gravity, and magnetic field on the heat exchange parameters in laminar flows in a circular cross-section tube. The research plan spans over 24 months and consists of 4 research tasks. Purposefully designed test setup will be used to determine the heat transfer performance of FNF. Similarity numbers will be calculated based on thermodynamic properties and acquired data: mass flow rate, inlet/outlet FNF temperature, test section temperature profile. Thermophysical data for selected commercial FNF is obtained from the manufacturer and based on preliminary measurements conducted at ILK Dresden. Similarity numbers and heat transfer coefficients will be compared with results available in the literature and preliminary research for horizontal configuration (carried out at ILK Dresden). The research effort will help in drawing conclusions about main mechanisms responsible of heat transfer process alternation.

Reasons for choosing the research topic: Convective heat exchangers are one of the most common heat transporting devices used in variety of contexts and applications. The underlying phenomena are complex, but there is a room and need for improvement. Being actively involved in the COST Action NanoUptake and NANOConVEX COST CIG allowed us to build confidence and interest and experience in the field of nanofluids and established many connections resulting in successful cooperation. The evidence accumulated in the process proved that nanofluids indeed offer enhanced thermal capabilities, but the lack of reproductible data for FNFs became painfully visible.

For the above reasons the outcomes of proposed project will improve the understanding of FNF-enhanced transport phenomena and therefore strongly impact the development of future convective heat transfer devices. The expected benefits range from simple reduction of investment and operating costs, all the way to new innovative applications (e.g., aerospace), improved storage and transport capabilities, reduced dependency on non-renewable energy sources, etc. The advances on heat transfer fluids are an important and mandatory step in the development of a balanced, more environmentally aware society powered by highly efficient green energy systems.