Nanofluids – colloidal suspensions of nanoscopic particles – are known to have anomalous properties due to unexpected structural, interfacial and Brownian motion effects. The same stands for nanoconfined fluids – fluids inside nanoscopic pores. Separately, both of these extraordinary objects are actively explored by scientific and engineering communities. In view of these studies, I expect a strong synergetic effect when combining both nanofluids and nanoconfinement in a single system – nanoconfined nanofluids (NNs). However, due to the methodological complexity of the problem, theoretical works on NNs are scarce, while experimental studies seem to be completely absent.

In this project, I intend to experimentally uncover potentially disruptive properties of NNs particularly in view of tribocharge and heat generation during nanofluid displacement inside a nanopore. I will exploit this knowledge for the development of a new type of triboelectric nanogenerator of unprecedented efficiency arising from nanoparticle-induced charge transfer and from typically ignored solid-liquid interfacial thermal energy, which will eventually allow to design energy harvesters capable of fully exploiting waste heat.

The goals of Nano^2-fluid project are the following:

- Introduce the concept of Nanoconfined Nanofluids (NNs)
- Experimentally reveal how int-ext induced tribocharging, heat generation, wettability (intrusion pressure) and nanobubble nucleation (extrusion pressure) depend on characteristics of nanoparticle (size, shape, conductivity, concentration) and nanoporous materials (pore size, topology, chemical composition, flexibility)
- Generalize the obtained knowledge and develop phenomenological framework for NNs in attempt to make this knowledge exploitable beyond triboelectric nanogenerators
- Design NNs optimized for tribocharge generation. Comprehensively study their characteristics depending on temperature, frequency and electromagnetic field further generalizing theoretical grounds
- Build and test first nanoconfined nanofluid-based triboelectric nanogenerators.

To reach these ambitious goals, I will apply a one-of-a-kind experimental methodology I have been developing to reveal tribocharging upon water intrusion-extrusion into-from superhydrophobic nanopores by simultaneous measurement of mechanical, thermal, and electrical energies involved in the process. Applying this approach to nanoconfined nanofluids will allow me to explore how nanoparticles affect tribocharge and heat generation, wettability and bubble nucleation during solid-liquid interface development-reduction inside a nanopore. The novel physical insights into the behaviour of nanofluids in complex nanoconfined environments are expected to inspire radically innovative strategies for triboelectric nanogenerators, nanopore sensing, nanofluidics, chromatography and ionic channels.