The transition from a fossil fuel-dependent economy towards an economy that utilizes renewable and low-carbon energy sources is one of the most important challenges facing the world today. Since CO_2 accumulated in the atmosphere is considered to be one of the most important factors contributing to global warming, efforts should be made to separate CO_2 from post-combustion gases, and consequently to reduce its emissions. In the chemical industry the demand for more flexible equipment and innovative production concepts, offering significant improvements in terms of energy efficiency and sustainability, including the removal of CO2 from flue gases, has increased remarkably in recent years. Rotating Packed Beds (RPBs) address both approaches by applying centrifugal force to improve the performance of mass transfer processes. Advantages of RPBs include modularity, high flexibility, intense mass transfer, high-throughput and very compact design resulting in potential savings in operation and investment costs. They can also be easily adapted to changing operating conditions through tailor-made design of rotors' internals which is the key aspect of the project.

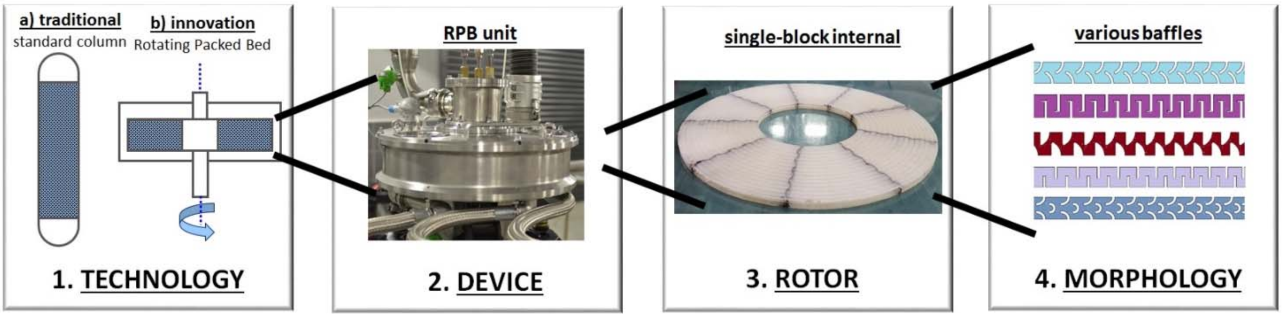

Figure 1 – Overall concept of the proposed project

The current state-of-the-art carbon capture technology is gas-liquid absorption in packed columns using amine-based aqueous solutions which bind CO_2 chemically (Fig. 1-1-a). However, that approach is burdened with substantial energetic and investment costs. We offer application of Rotating Packed Beds (RPB), in which centrifugal force replaces gravity as driving force for liquid flow within the apparatus (Fig. 1.1.b). The core element in an RPB unit (Fig 1.2) is the rotor equipped with various internals (Fig. 1.3). We focus on single-block design (Fig. 1.3) formed by concentric baffles of various morphologies (Fig. 1.4). The single-block structure of internals provides good mechanical stability and thus allows using 3D printing for the manufacturing of customized internals. Within this project, a method of rapid prototyping of tailor-made internals by additive manufacturing ("3D printing") is proposed as a research problem to be investigated. In the project, we will focus on developing a method for computer-aided design of internals' structures, i.e. optimizing the shape and arrangement of inner channels and baffles, and then, on prototyping of internals by additive manufacturing techniques. Consequently, using the gained knowledge, innovative tailor-made internals will be manufactured and tested experimentally. Ideally, the internals allow for low pressure drop (and thus for high energy savings), high holdup (and thus for improved absorption efficiency) and increased mass transfer (and thus for lower investment costs). We will pave the way for rapid development of the internals' morphology (effective surface area, internal structure etc.) to reach the most efficient and energy-saving gas processing in CO_2 absorption.

In this project, computer-aided design method, which numerical modelling, rapid prototyping with the use of additive manufacturing, and eventually experimental studies, will be executed to investigate the performance of the developed tailor-made internals. We have defined the following specific research objectives:

- Development of an advanced method for simulation of fluid hydrodynamics in rotating internals using computational fluid dynamics (CFD).
- Identification of internal morphology allowing for the lowest energy consumption and highest absorption performance
- Development of methods for computer-aided design and additive manufacturing of new internal morphology.
- Experimental validation of the developed approach of rapid prototyping of rotating internals with CO_2 absorption in amine-based solvents as a case study.