Energy was always necessary for rapid social development. Worldwide, rapid industrialization and the extensive use of fossil fuels for power plants and automobiles is increasing day by day, resulting in not only environmental pollution, but also economic and diplomatic problems. Moreover, the fossil fuels are limited and being consumed rapidly. Recent years showed that the cost of obtaining energy from traditional non-renewable sources is increasing in a manner difficult to predict. Unfortunately, at the moment more than 80% of energy in the world are derived from fossil fuels alone. The solution to these problems is utilization of renewable energy sources such as biomass and energy of the Sun. The necessity of recycling and use of organic compounds contained in waste materials and wastewater is inevitable. However, regardless of the source, the energy has to be delivered to the user through an efficient carrier, that can be used in a wide range of applications. Hydrogen is considered to be one of the most promising fuels of the future, and is widely recognized as a potential substitute for fossil fuels, mainly because it is versatile, energy-efficient and low-polluting fuel. However, currently about 98% of hydrogen comes from fossil fuels. Biological hydrogen production provide an alternative method for generation of renewable hydrogen, mainly because these processes are operated at ambient temperature and atmospheric pressures, thus are less energy intensive and more environmentally friendly as compared to thermochemical and electrochemical processes. In particular, conversion of organic substrates to hydrogen through dark fermentation and photofermentation is of great interest. These processes can use a variety of organic substrates as a carbon source, so that they offer a dual function of waste reduction and hydrogen energy production.

Anaerobic bacteria produce H_2 during dark fermentation of organic substrates by using protons as an electron sink. Dark fermentation has the advantage of high H_2 production rate and utilization of complex forms of organic substrate such as starch, cellulose or municipal wastes. However, the theoretical maximum hydrogen yield in dark fermentation is only 4 mol H_2/mol glucose. The by-products are mainly composed of volatile fatty acids (VFAs) such as acetic acid, butyric acid and propionic acid, thus the effluent needs to be treated being released into the environment. However, These soluble metabolise can be further utilized via photofermentation (with purple nonsulphur bacteria) resulting in additional H_2 production at the expense of light energy. Integration of these two bioprocesses could theoretically yield 12 mol of hydrogen per 1 mol of glucose.

The main aim of this project is to develop and investigate a novel continuous system of biohydrogen production created by coupling dark and photofermentation. The research will focus on applying complex substrates (cellulose) to take full advantage of the complementary capabilities of dark and photofermentative bacteria. This project involves the design and investigation of the novel integrated bioreactor divided into dark and photo chambers by a porous materials. In created hybrid system volatile fatty acids (VFAs), which are products of the dark fermentation, will diffuse through the porous membrane and then will be consumed by the photofermentative bacteria, leading to the total reduction of substrate to hydrogen and carbon dioxide. The essence of the project is examination of different macromolecular compounds as substrates for the process, because they are the main component of many agricultural and food industry wastes and wastewaters. Another goal of this project is to develop and characterize stable H_2 producing mixed bacterial consortia composed of several different microorganisms. An important objective will be understanding the key metabolic interactions and dynamics of microbial population associated with changes in its composition during the long-lasting continuous processes. It is assumed that the composition of microorganisms will adapt to changing conditions inside the bioreactor. It is essential to determine how changes in the composition of the bacteria affect the performance of gaseous and liquid metabolites production. Research carried out in this project will allow to determine the optimal parameters of the hybrid process (hydraulic retention time, organic loading rate, pH, type and concentration of nitrogen source) and provide information about kinetics and stability of hydrogen production in a continuous system.