SPEECH INFORMATION (For Conference Program Book)	
Topic	Current State of Research and Development of Microorganisms in Net-Zero Technologies
Abstract	Microorganisms play a pivotal role in the sustainable generation of bioenergy, particularly bioH_2 and bioCH_4, through dark fermentation processes, which is deemed the most commercially feasible biological method for H_2 production due to its high production rate and substrate versatility. Research efforts focus heavily on optimizing microbial communities and operational parameters to efficiently convert complex organic wastes, such as industrial wastewaters, food waste, and lignocellulosic hydrolyzates, into valuable energy carriers. In the acidogenic phase of dark fermentation, the primary efficient hydrogen-producing bacteria in mixed cultures belong to the genus, *Clostridium* such as *Clostridium butyricum* and *Clostridium pasteurianum*. A core strategy to enhance H_2 production is the selective enrichment of these spore-forming, acidogenic bacteria while inhibiting hydrogen-consuming methanogenic archaea. This selection is typically achieved through harsh pretreatment methods of the seed sludge, such as heat treatment or acid treatment. Furthermore, maintaining optimal operational conditions, specifically a low pH (often maintained at 5.5–6.0), is critical for stabilizing the H_2 production phase. A significant engineering challenge in continuous, high-rate bioreactors is mitigating cell wash-out at short hydraulic retention times. This limitation is circumvented by cell immobilization technology, which dramatically improves overall process stability and productivity by maintaining high concentrations of active biomass within the reactor. Common immobilization techniques involve embedding microorganisms in materials like EVA copolymer, utilizing powdered activated carbon, or operating systems such as the agitated granular sludge bed reactor. To achieve maximal energy recovery, integrating H_2 fermentation with subsequent methane fermentation in two-stage systems (producing biohythane) is considered highly advantageous. Recent innovations include the development of the internal two-stage bioreactor or two-compartment bioreactor, which simplify the fermentation cascade by separating the acidogenic (hydrogenesis) and methanogenic phases within a single reactor unit. In the methane-producing compartment, the dominant archaea include the phylum Euryarchaeota, with key methanogenic families such as Methanosaetaceae and Methanobacteriaceae and Methanomicrobiaceae. Pilot-scale implementation developed by the Feng Chia University team, demonstrates the engineering feasibility of high-rate systems. Furthermore, economic assessments of two-phase H_2/CH_4 systems processing sugary wastewater indicate promising commercial viability with economy analysis. This two-stage system, known as HyMetek, represents a promising technology for achieving net-zero emissions.