**Introduction**

In order to prevent disastrous consequences of climate change society must transition away from fossil fuels and towards a carbon-neutral economy. Bio-methanation, the biological production of renewable and carbon-neutral methane, presents an exciting opportunity to move away from fossil fuels. Traditional biomethanation techniques such as anaerobic digestion convert sewage and other waste into biogass, mixture of carbon dioxide, hydrogen, and methane gas, of variable quality. Biogas upgrading via hydrogenotrophic methanogenesis is a technique by which biogas can be converted into useable methane fuel. Hydrogenotrophic methanogens useful as a hydrogen storage method. Hydrogen is a carbon neutral fuel but is not compatible with existing energy infrastructure. Converting hydrogen into renewable methane derived from waste allows for carbon netural fuel to replace existing fossil-fuel derived from methane without changing infrastructure such as pipelines and appliances.

Here an anaerobic microfiber bioreactor is used for biogas upgrading via hydrogenotrophic methanogenesis. Influent H2 and CO2 are converted to high quality (>90%) biogas. The h2-co2 to ch4 oxidation reaction is optimized at a stoichiometric ratio of 4:1 H2:CO2. Traditional bioreactor concepts struggle to deliver substrate gases to microbes because of gaseous CO2’s higher solubility than H2. The MfBr resolves this issue by using microporous polymer membranes to deliver gaseous hydrogen directly to the microbiome. Microbes grow on the surface of the membranes, which span the length of the reactor and diffuse H2 gas directly into the biofilm. CO2 is delivered via sodium bicarbonate.

Existing research has established operation parameters that optimize methane production and biogas output. The group metabolism of the metabolic communities in methane-producing bioreactors, however, is less well understood. The main biochemical pathway which produces methane is the reduction of H2 by the Acetyl-CoA pathway. This pathway is present in a variety of anaerobic archaea taxa, including *methanobacteria* and *methanosarcina.* However, a mixed culture inherently contains microbes which are capable of a number of other biochemical pathways, many of which are relevant to biomethane production. For example the Wood-Ljundal pathway, which many anaerobic bacteria posses, convert carbon dioxide and hydrogen into acetic acid and a number of related compounds. Other archaea in turn convert acetic acid into methane.

These reactions along with many others create a complex web of metabolic reactions which is termed the microbiome metabolism. Here, genome reconstruction is used to create a computational model of microbiome metabolism. This model is used to investigate the optimal media feed concentrations, microbiome concentrations, and operational parameters for methane production.

**Methods**

The Reactor