

WP3: Biomass Analysis, PhD Project description, DTU-E**Background and motivation:**

This PhD research is part of a BioChain project financially supported by a grant from the Danish Council for Strategic Research (Commission on Sustainable Energy and Environment). The BioChain project aims to provide scientifically based, sound solutions for resilient and sustainable large scale biogas production in Denmark through intensive and comprehensive value chain framework analysis and computational models that can help to make investment and political decisions in the future Danish biogas and renewable energy production, also offers financial overview for investors and greenhouse gas emission of the biogas value chain. The integrated value chain framework analysis will be able to identify the barriers and hurdles in the current Danish biogas production value chains that hinder to exploit the available nationwide maximum biogas potential. Henceforth, solutions to remove the challenges in the biogas value chain process will be suggested based on scientific analytical, theoretical, computational, logistics and economical methodologies. Accordingly, WP3 will develop analytical systematic biogas quantification method and computational model that can be used as input to WP1, value chain optimization.

Objectives of the research:

The overall purpose of the research is to develop rapid and reliable analytical method and computational model that predicts biochemical methane potential of various ranges of household and industrial organic waste fractions as well as investigate the effect of hydraulic retention time(HRT) and co-digestion of organic household waste with garden waste and wastewater treatment primary sludge in continuous stirred tank reactor(CSTR) and also quantification of fugitive greenhouse gas(GHG) emissions from a full scale biogas production plant.

Methodology:*Activity 1: Rapid Biochemical methane potential (BMP) Analysis*

Partial least square (PLS) model will be built using BMP data from batch assay (VDI 4630) and NIR spectra obtained with optimal data pre-processing. The spectra and methane yield of household and industrial organic waste fractions will be input to develop a computational model that predicts BMP.

Activity 2: Co-digestion and Effect of HRT on biotransformation of organic pools in CSTR's

The proposed test involves running continuous stirred tank reactors (CSTRs) with household waste, co-digestion of household waste and garden waste (green waste), co-digestion of wastewater treatment plants (WWTPs) primary sludge and household waste and also digestion of primary sludge without co-substrate at various hydraulic retention time (HRT) and optimal biogas production reactor condition. Inoculum will be collected from waste water treatment plant anaerobic digesters and also from reactors running with household waste as feedstock.

Activity 3: Quantification of Fugitive Emissions

The rate of fugitive greenhouse gas (GHG) emission is computed based on measured downwind plumes of greenhouse gases in an appropriate distance from the biogas plant that in turn will be compared to known rate of released tracer gas at the emission source. The atmospheric concentration will be measured by methane/acetylene and nitrous oxide/nitrate analyzers, based on cavity ring analytical approach. The analyzers have GPS feature to relate the measured concentrations with the local geographical area.

Deliverables:

- ✓ The expected outcome of the research based on NIR analysis is rapid and reliable analytical method and computational model that predicts biogas production.
- ✓ The outcome of CSTRs research is kinetic constant parameter, detailed physicochemical characteristics of substrates and co-substrates during anaerobic conversion and physicochemical composition of digestate.
- ✓ Quantification of fugitive GHG emissions from a full scale biogas plant.

Timeline of Activities

CSTR,BMP Model Development & Quantification of Fugitive Emission	2014				2015				2016			
	Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Nov
CSTR 1: HHW & HHW+GW	X											
CSTR2:HHW & HHW+GW		X										
CSTR3:HHW & HHW+GW		X	X									
CSTR4:Sludge & Sludge + HHW			X									
CSTR5:Sludge & Sludge + HHW			X	X								
CSTR6:Sludge & Sludge + HHW				X								
Batch BMP Assay Set Up & NIR 1					X							
Batch BMP Assay Set Up & NIR 2						X						
Batch BMP Assay Set Up & NIR 3							X					
Batch BMP Assay Set Up & NIR 4								X				
Batch BMP Assay Set Up & NIR 5									X			
Batch BMP Assay Set Up & NIR 6										X		
BMP PLS Model development											X	
Mass Balance						X						
Fugitive emission measurement campaign						X						
Fugitive emission Quantification							X					
Journal Article manuscript writing					X				X		X	
Ph.D Thesis writing											X	X