



Optimisation of Anaerobic Digestion by MIR, NIR, UV/VIS online spectroscopy

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Agenda

- Sensor Technology
 - VFA Sensor
 - Gas Sensor
- Optimisation of digester operation
 - Existing approach
 - Goals & How to get there
 - Lab testing
 - Simulations

SENSOR TECHNOLOGY



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Sensor Technology

- Testing is now completed with newly developed sensor prototypes.
- Tested prototypes for VFA sensor and for biogas sensor.
- Next stage is to come up with an optimization strategy to make the best use of the measured data.
- Also want to create a strategy that is independent of sensor technology.

VFA Sensor

- At present sensor still needs improvements beyond what are possible as part of this project.
- Minimum concentration for detection is too high at present.

Gas Sensor Testing

- Continued MEMS sensor testing.
- Had some software problems which are now fixed.
- Testing completed in 3 locations:
 - CSTR lab setup in Teagasc.
 - Pilot scale biogas plant.
 - Landfill gas site.
- Still need to analyse some results.

CSTR Setup Installation



Landfill gas site installation



OPTIMISATION

Optimisation questions

- How to use the data from the sensor?
- How to select optimum level for an individual digester?
- Which technology can be used?

Existing Approach

- By J-P Steyer et al. [1].
- Assumes constant feeding rate.
- Increases feeding rate by 30% for several hours.
- Looks at change to rate of gas production.
- If digester is approaching inhibition then response is slower.

[1] Steyer, J.-P., Buffière, P., Rolland, D., Moletta, R., 1999. Advanced control of anaerobic digestion processes through disturbances monitoring. Water Res. 33.

Possible Areas for Improvement

- Could this work for intermittently fed reactors?
- Could this work with a decrease in feeding rate?
- Do VFA concentrations change in a similar way?
- Can gas rate measurements be combined with VFA measurements to set VFA thresholds?

End Goals

- Using existing instrumentation for intermittently fed reactors, determine optimum level.
- Using FOS/TAC analyser and gas meter, come up with feeding regime to determine optimal level.
 - Example: Adjust feeding profile and take FOS/TAC readings. Use gas profile data to determine how close to optimal digester is running, and set new targets for FOS/TAC measurements.

Steps to investigate these questions

- First perform testing with laboratory CSTR setup to generate real expected results and show trend approaching inhibition.
- Perform simulations and ensure simulations match reality.
- Use simulations to make predictions for future experiments.
- Validate simulations with further tests on CSTRs and pilot scale digester.

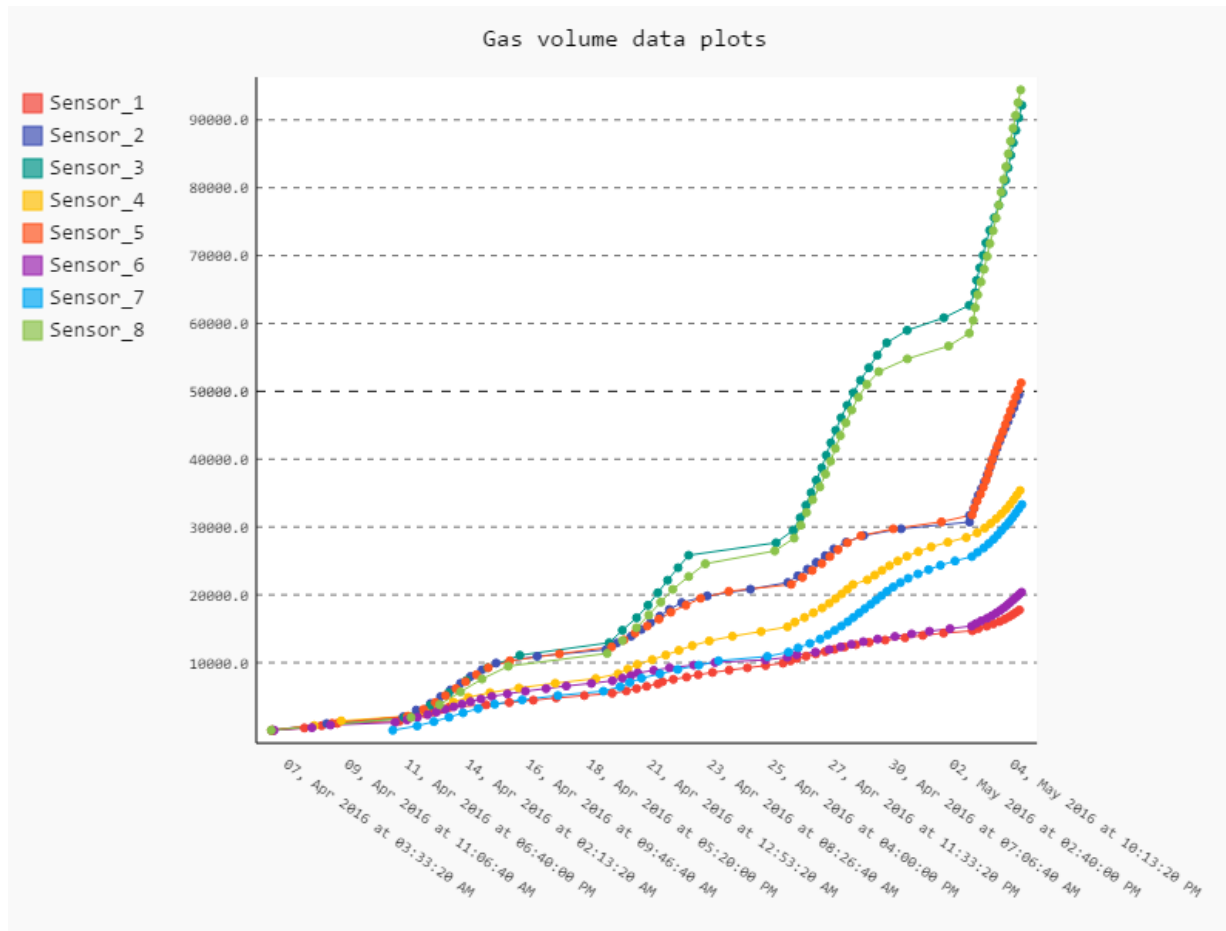
CSTR Setup

- As part of secondment at Teagasc with Himanshu, carried out lab testing on CSTR setup.
- Fed different substrates, with increasing rates of VS to investigate change of gas production profile when approaching inhibition.

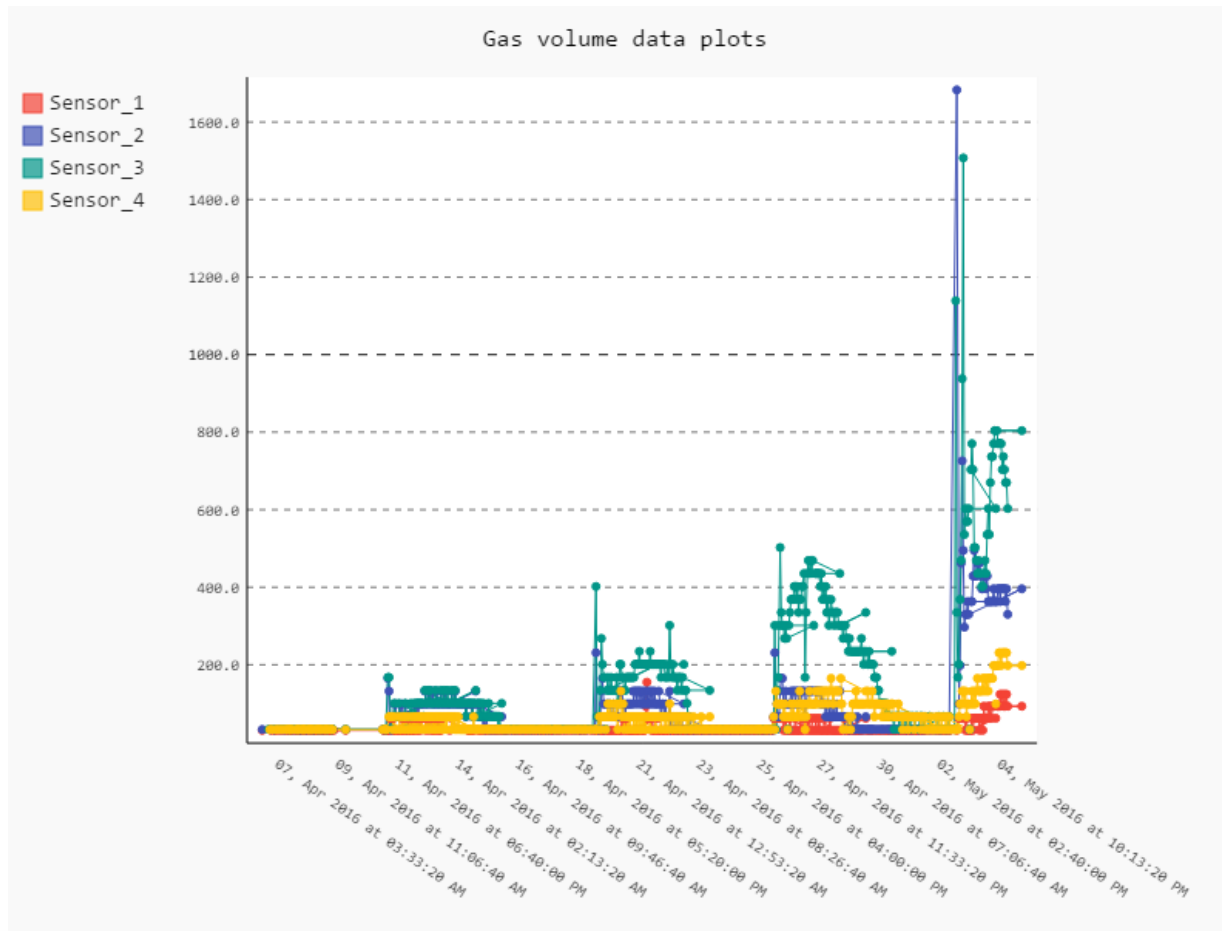
Lab testing



Cumulative Gas Production Plot



Rate of Gas Production



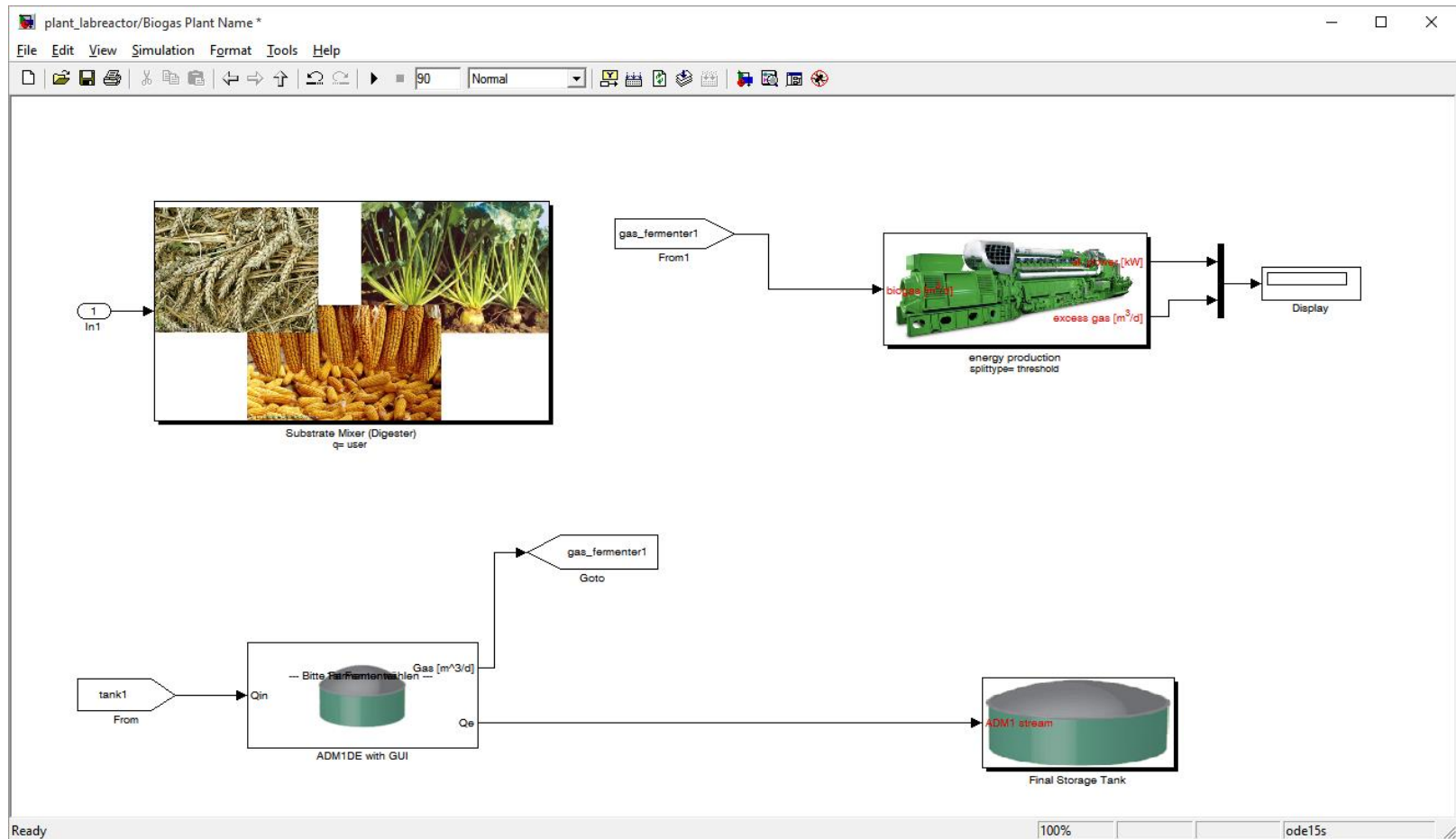
Lab testing measurements

- Total gas production.
- Gas bags for average gas composition from each day.
- Online gas composition for one reactor with MEMS sensor.
- Samples for VFA measurement in GC.

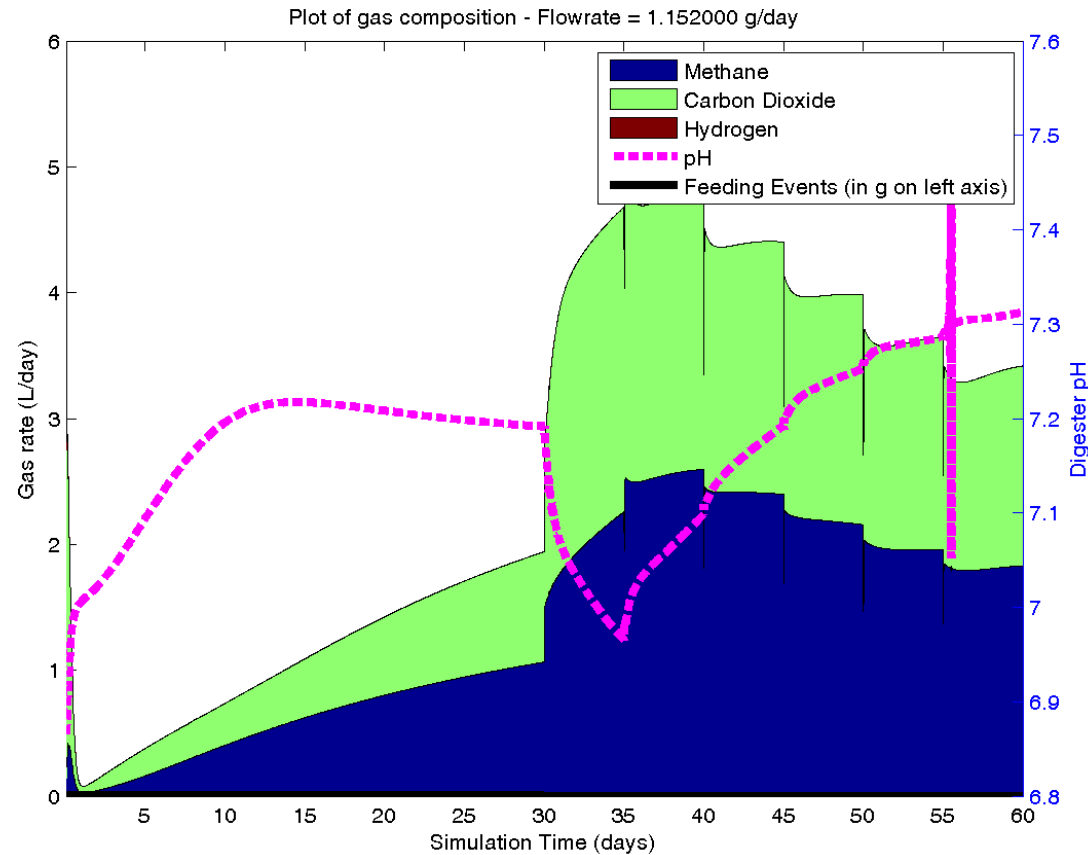
ADM1 Simulations

- Using ADM1 Matlab Toolbox implemented by Daniel Gaida.
- Created a replica of plant model and feeding regime.
- Can then modify parameters to ensure starting point matches reality.

ADM1 Simulations



Simulation Example Result



Simulations

- Still need further work to get simulations matching lab testing.
- Believed that this is due to parameters such as disintegration rate in the simulation model.
- Model hasn't accounted for milling as pretreatment.

Summary

- Sensor testing is completed.
- Optimisation techniques exist but have room for improvement.
- Performed lab testing and measurements.
- Currently trying to get simulations to match lab results.
- Goal is to devise a technique that will work independently of sensor technology.
- Technique will be created using simulations and then verified using lab & pilot scale reactors.



Thanks for listening



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