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Monitoring and control of anaerobic digestion for optimal biogas production

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Gas Transient Response & Intermittent Feeding

OPTIMISING INDIVIDUAL DIGESTERS

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Current State Of Instrumentation

- Instrumentation is generally lacking.
- Generally, a few easy to measure parameters are monitored.
- VFAs are one of the most important parameters, but not possible to measure online affordably.
- Each reactor has individual optimum level.

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Gas transient response for optimisation

- Previous work completed by J-P Steyer et al. [2].
- Method only suitable for continuously fed systems.
- Principle is that as digester approaches inhibition, digester response to feeding events changes.
- Only uses gas production rate.

- This project is investigating applicability to intermittently fed reactors.

[2] Steyer, J.-P., Buffière, P., Rolland, D., Moletta, R., 1999. Advanced control of anaerobic digestion processes through disturbances monitoring. Water Res. 33, 2059–2068. doi:10.1016/S0043-1354(98)00430-8

Why feed intermittently?

UK Electricity Market System Buy Price

Source: http://www.bmreports.com/bsp/SystemPricesHistoric.htm - Data for 31/08/2016, Retrieved 01/09/2016

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Intermittent Electricty Production

- Shift towards renewable energy.
- Biogas is well positioned to provide flexible electricity generation.
- Solar & Wind weather dependant, not controlled.
- Electricity is expensive to store.
- Gas is easier & cheaper energy storage medium.
- Gas production can also be controlled to increase production as required.
- Balancing electricity is more valuable than base load electricity.

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Intermittent Feeding

- Can produce higher value electricity for use balancing the power network.
- Flexible energy production is possible by large changes to feeding rates.
- Allows higher gas production as required than through continuous operation.
- Study by Hahn, et al concludes that flexible biogas production can be implemented with limited risk of process disruption [1].

[1] Hahn, H., Krautkremer, B., Hartmann, K., Wachendorf, M., 2014. Review of concepts for a demand-driven biogas supply for flexible power generation. Renew. Sustain. Energy Rev. 29, 383–393. doi:10.1016/j.rser.2013.08.085

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Intermittent Feeding Test setup

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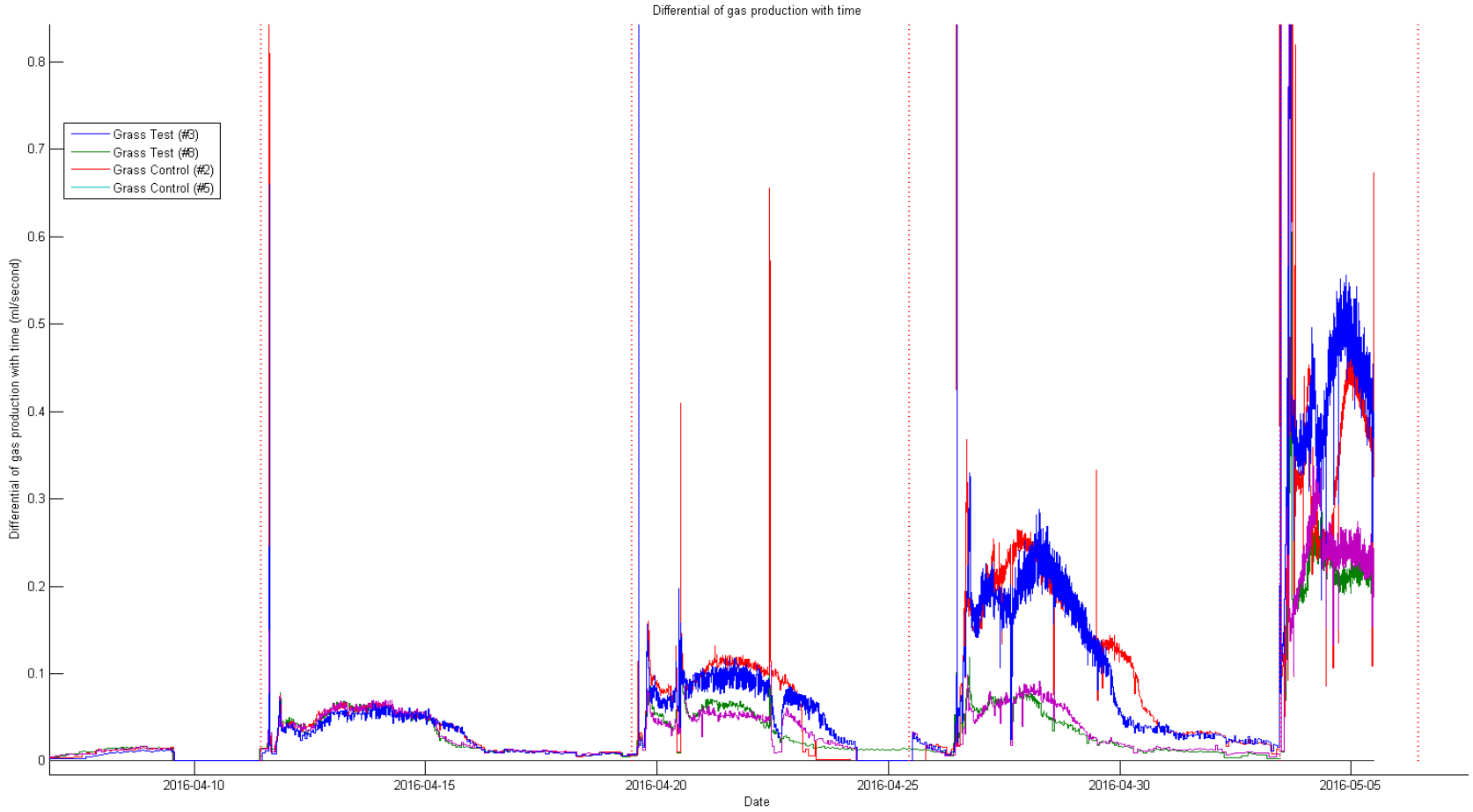
Gas Production Rate



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Testing, Modelling & Simulation

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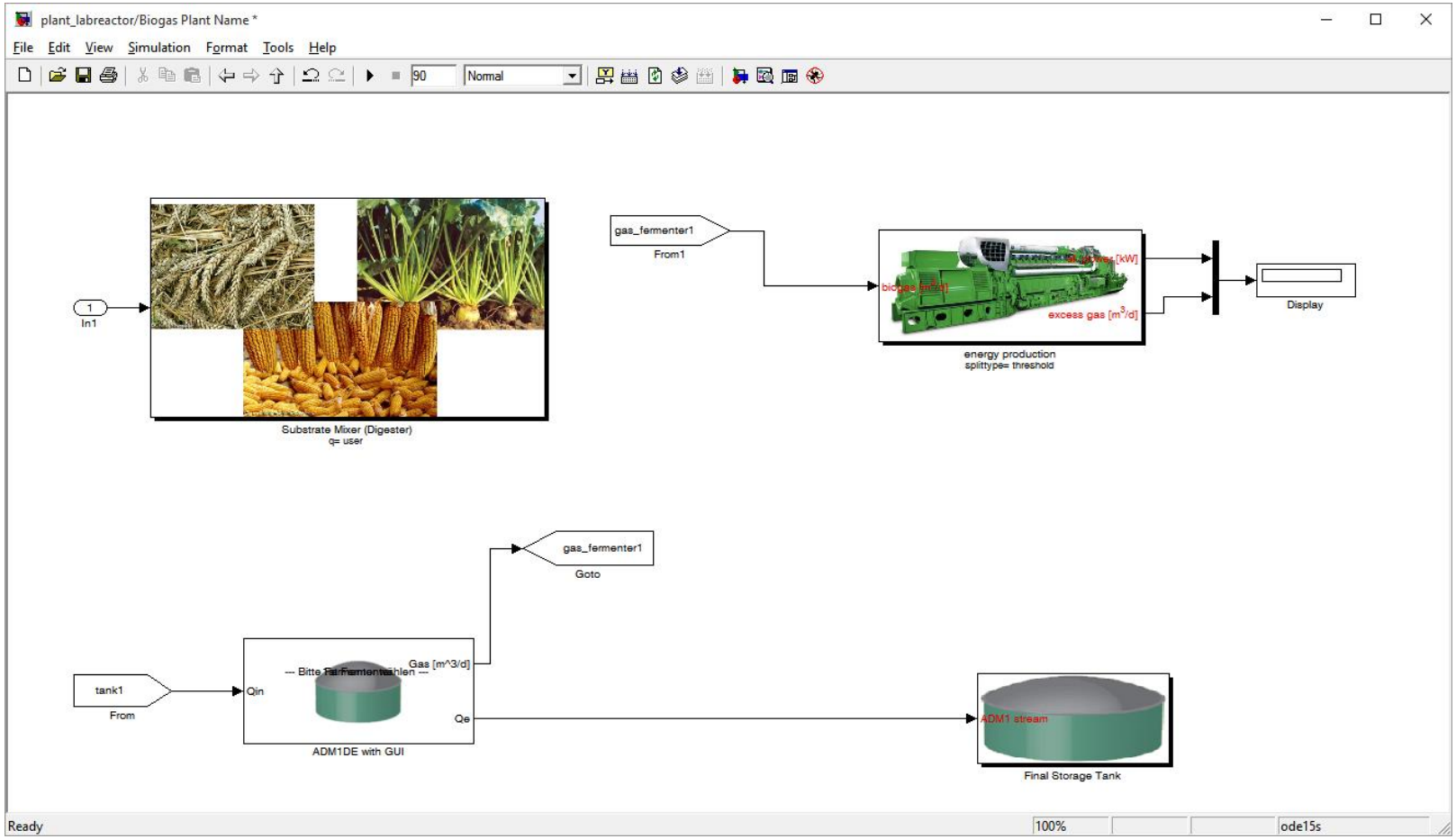
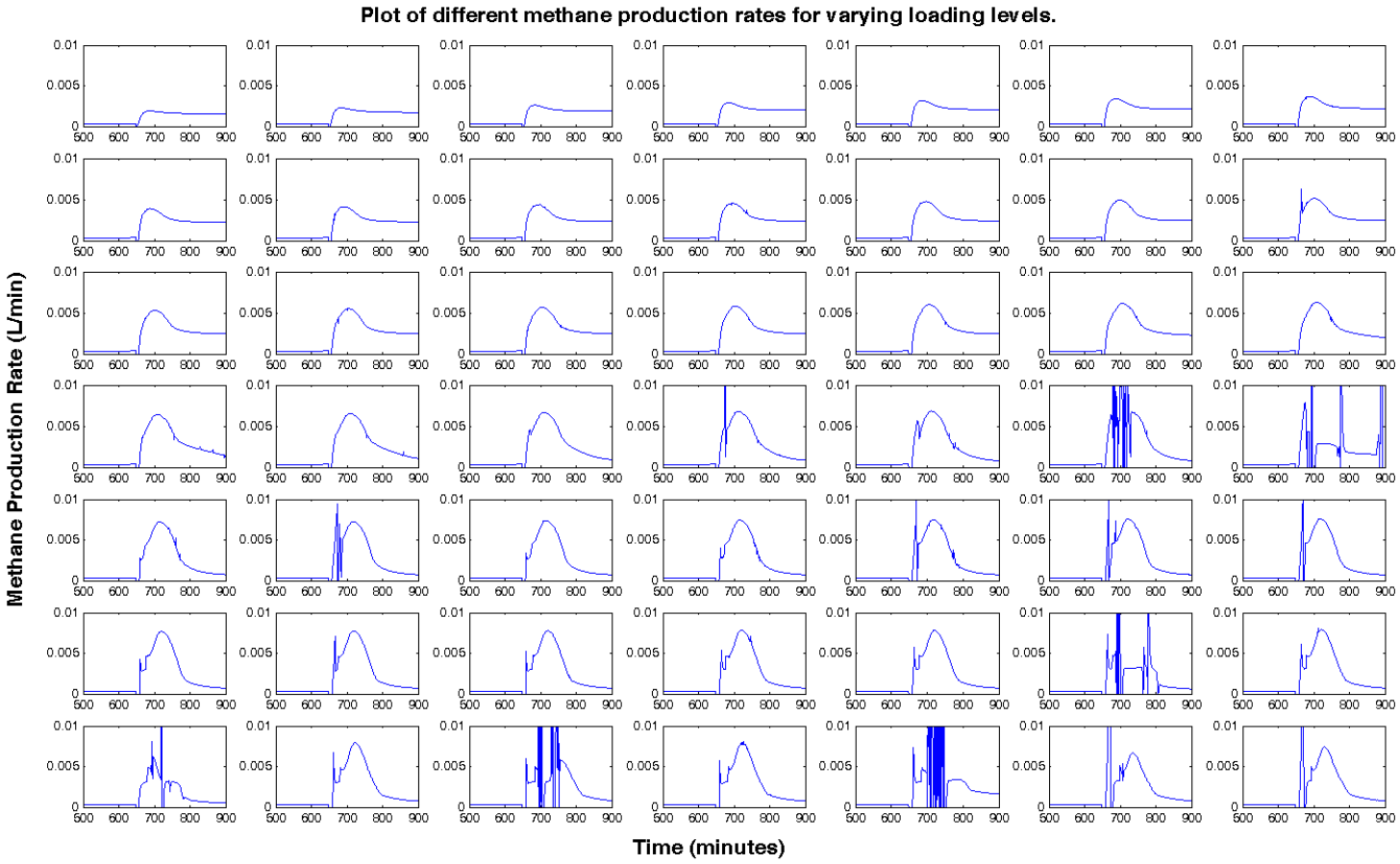
ADM1 Simulations



Multiple Different Scenarios Simulated



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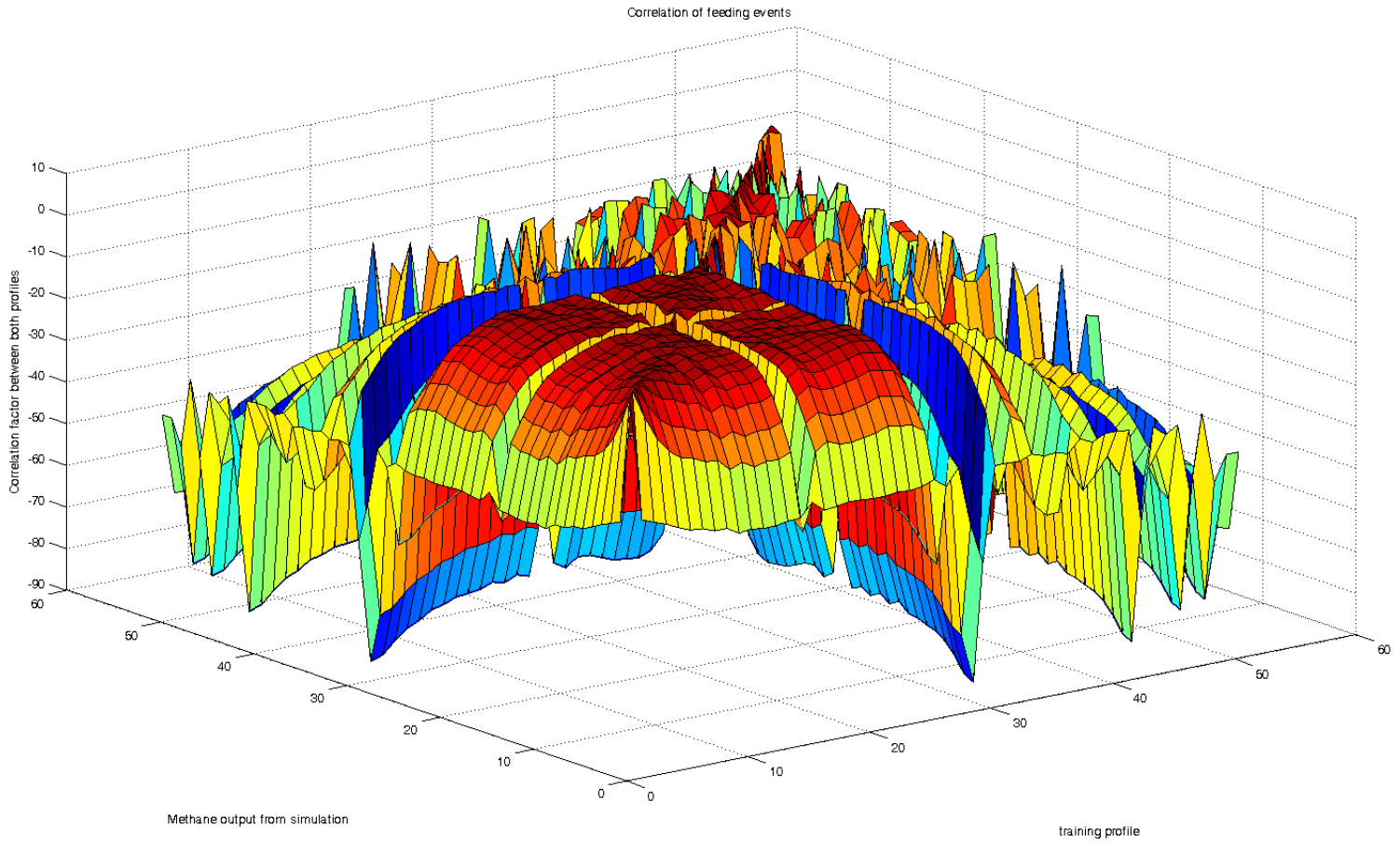
Feeding Event Similarity



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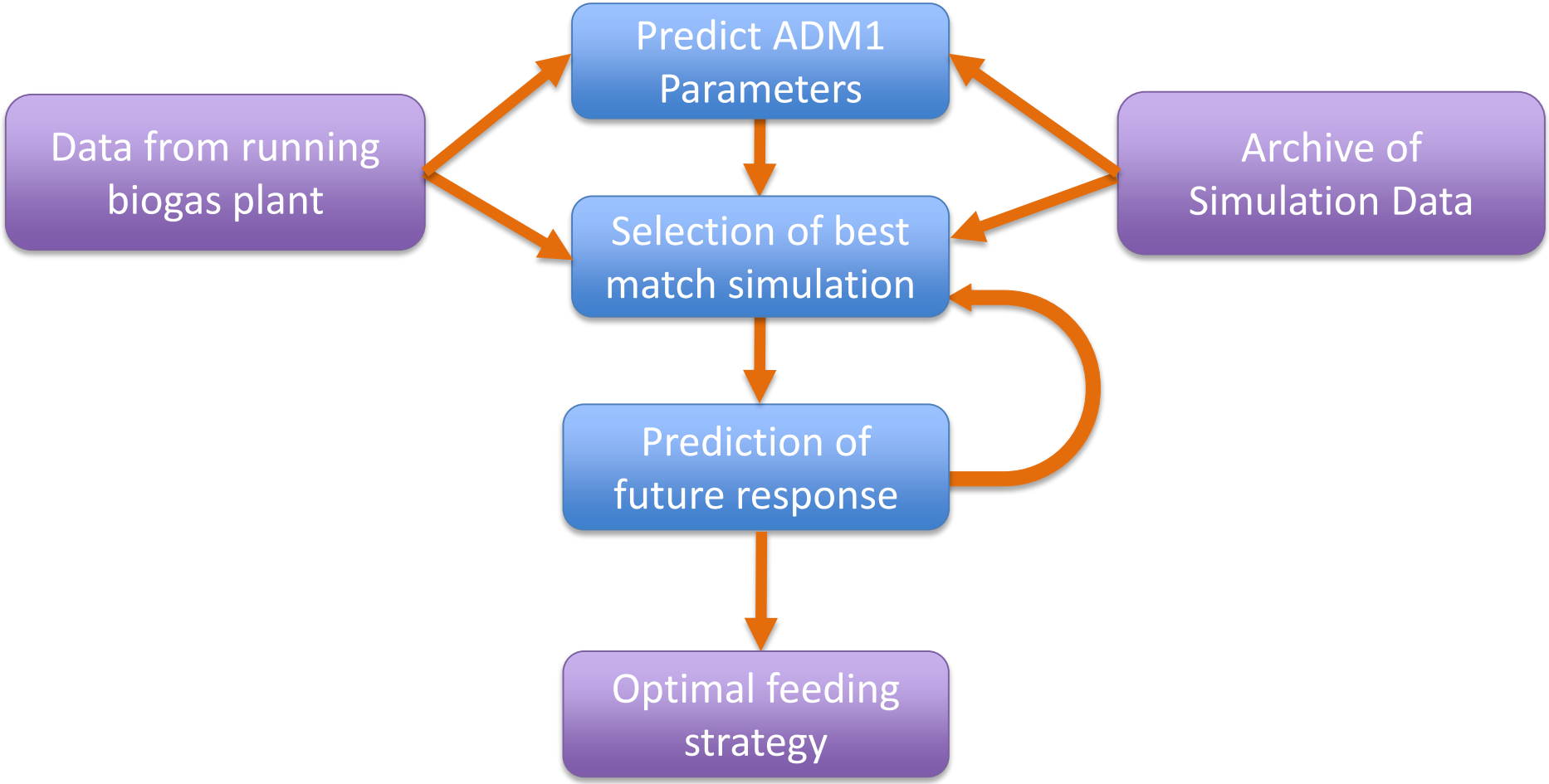
Model Implementation



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Challenges to Address

- Differentiate between
  - Differences due to substrate.
  - Variation due to loading rate.
- Determining Substrate Feed parameters.

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Next Steps

- Investigate link between VFA levels and methane production rate response curves.
- Attempt to create control strategy which allows better use of available measurements.
- Run simulations with control strategy.
- Test strategy with lab scale / pilot scale reactors.

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Goals for this task

- To use modulation in feeding levels and transient gas responses to understand digester operating condition.
- To set VFA thresholds which are the optimum for individual reactors.
- To produce a feeding & measurement technique that allows optimisation of biogas production whilst maintaining plant stability.

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Conclusions

- Biogas production may have to shift towards intermittent production to stay profitable.
- This feeding modulation should be sufficient to optimize biogas reactors on an individual level.

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Thanks for listening

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n. 316838

Project coordinated by the QUESTOR Centre
at Queen's University Belfast
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