Optimising Feedstock Flowrate to Improve the Performance of an Existing Anaerobic Digestion System

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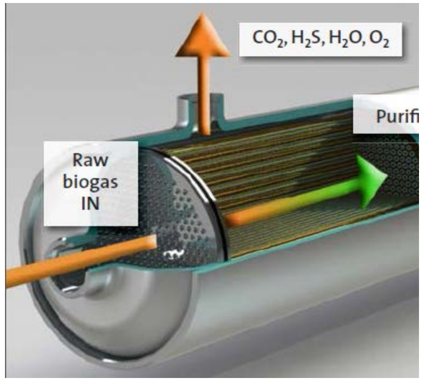
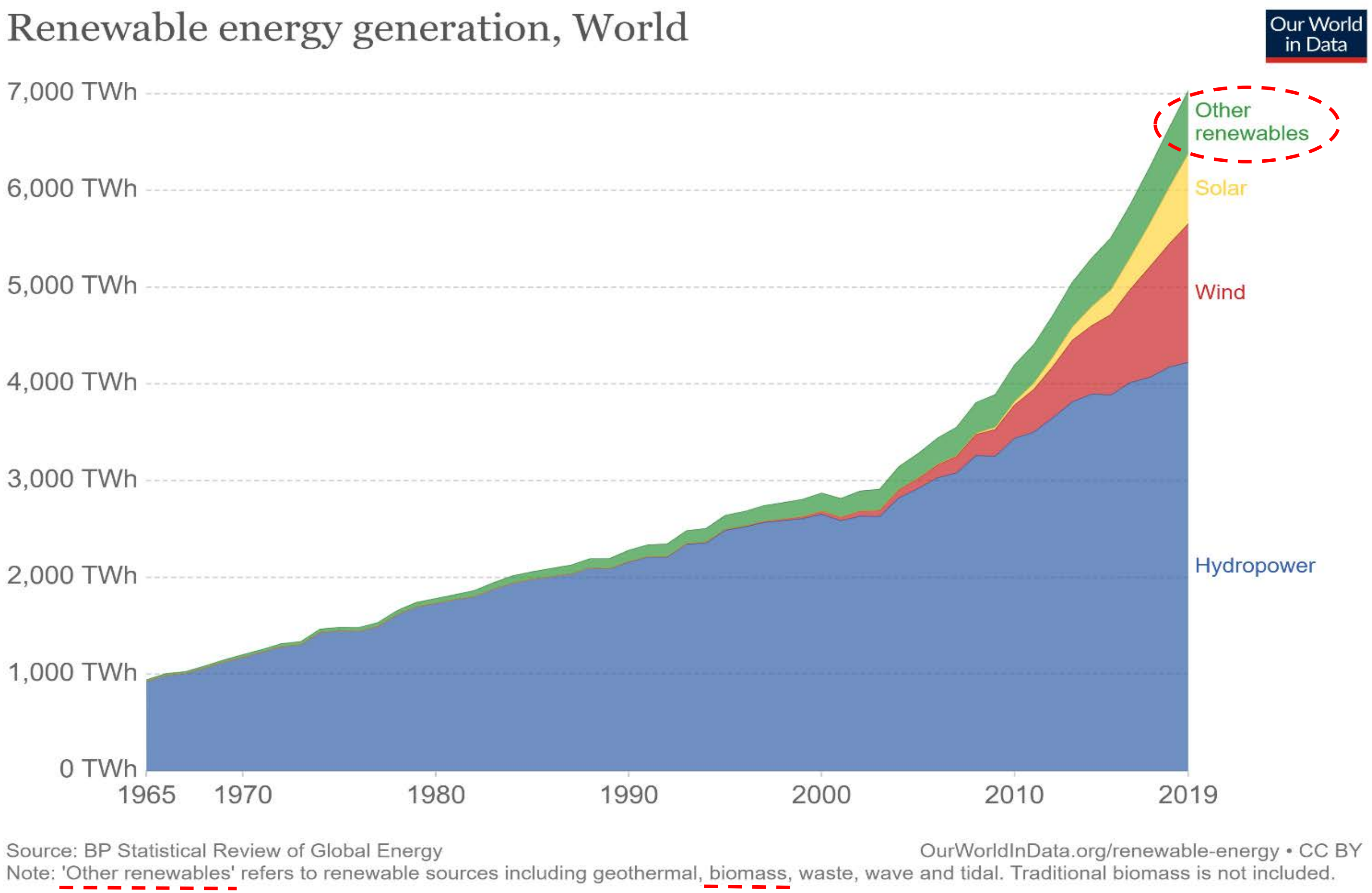
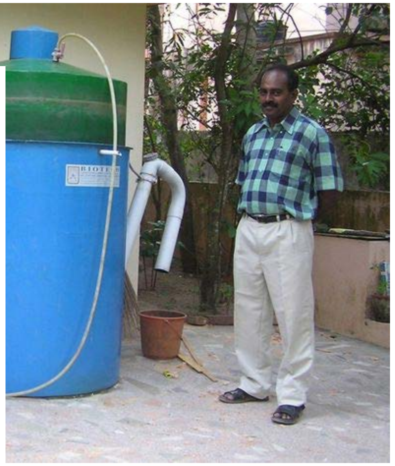
Background



CO_2, H_2S, H_2O, O_2
Purifi
Raw biogas IN

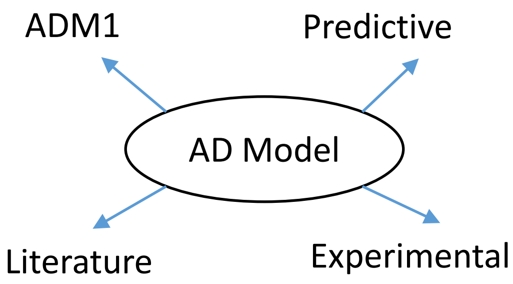


Renewable energy generation, World
Our World in Data
7,000 TWh
6,000 TWh
5,000 TWh
4,000 TWh
3,000 TWh
2,000 TWh
1,000 TWh
0 TWh
1965
1970
1980
1990
2000
2010
2019
Other renewables
Solar
Wind
Hydropower
Source: BP Statistical Review of Global Energy
OurWorldInData.org/renewable-energy • CC BY
Note: 'Other renewables' refers to renewable sources including geothermal, biomass, waste, wave and tidal. Traditional biomass is not included.

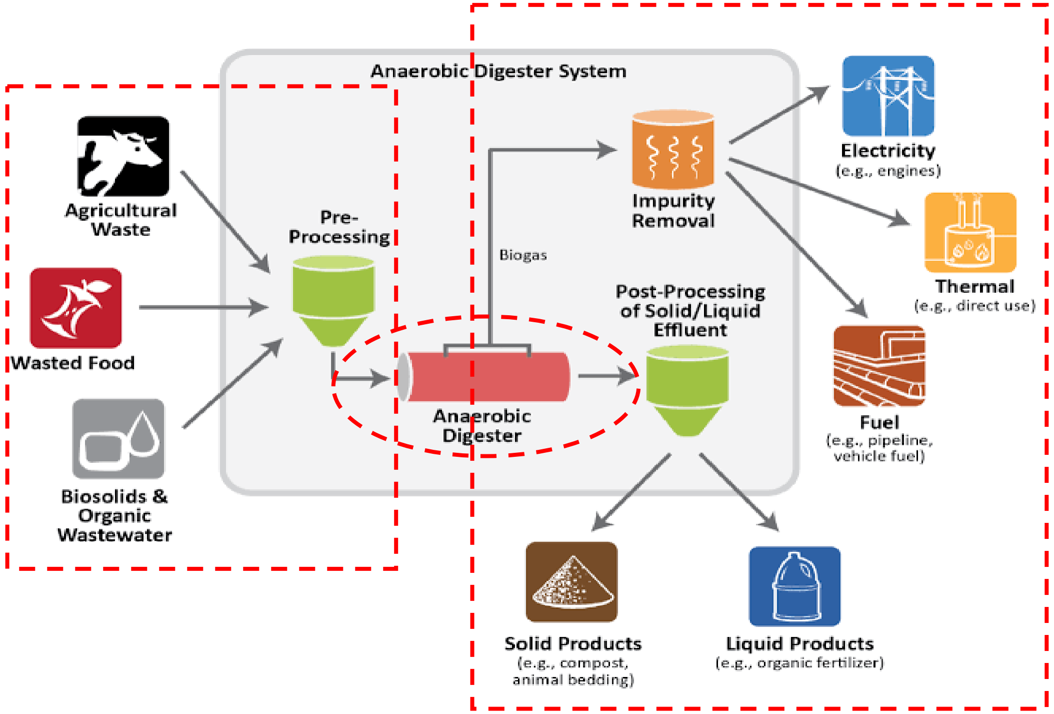


Problem Statement

“What if we don’t change at all …
and something magical just happens?”



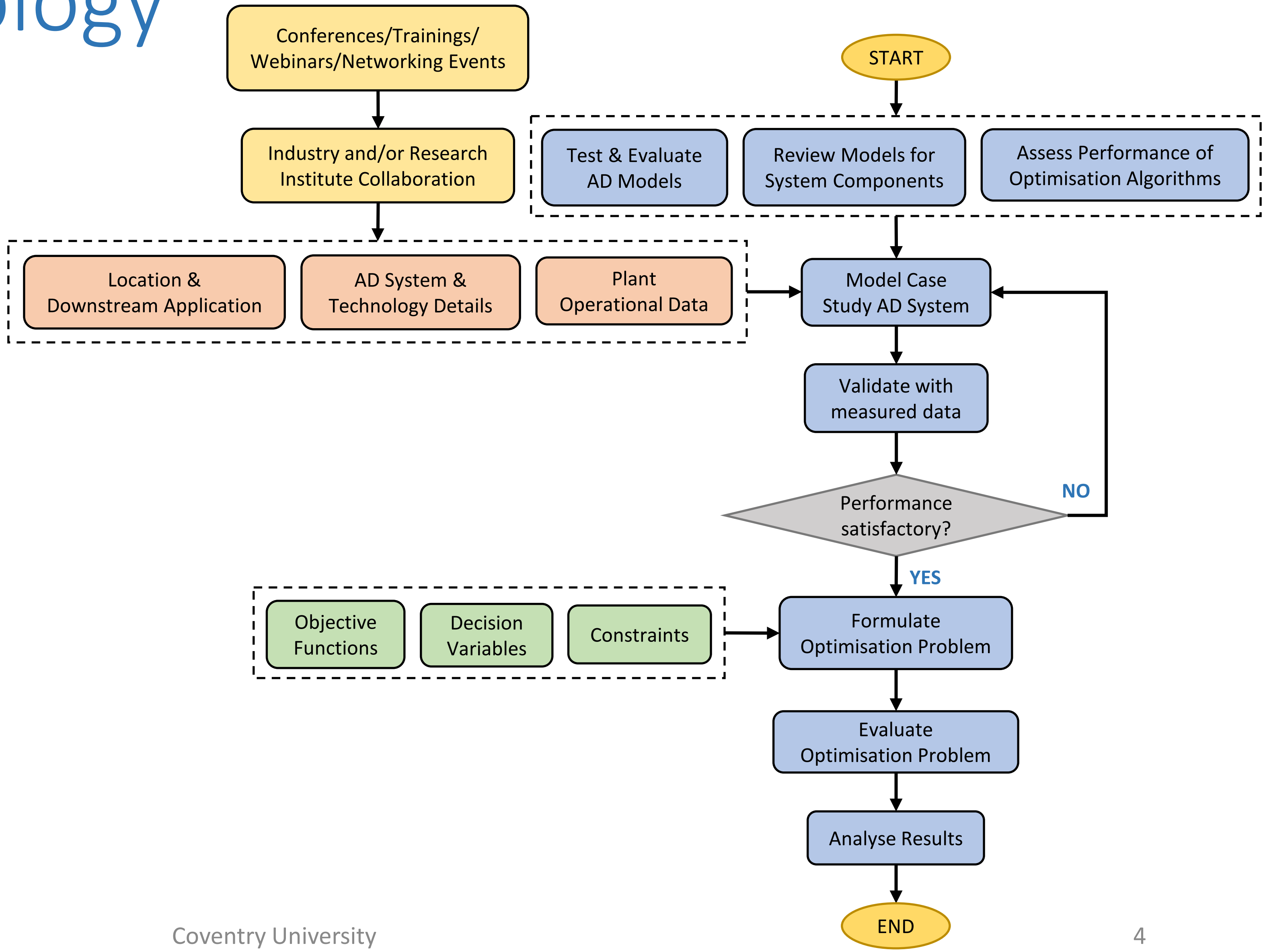
STANDARDIZED



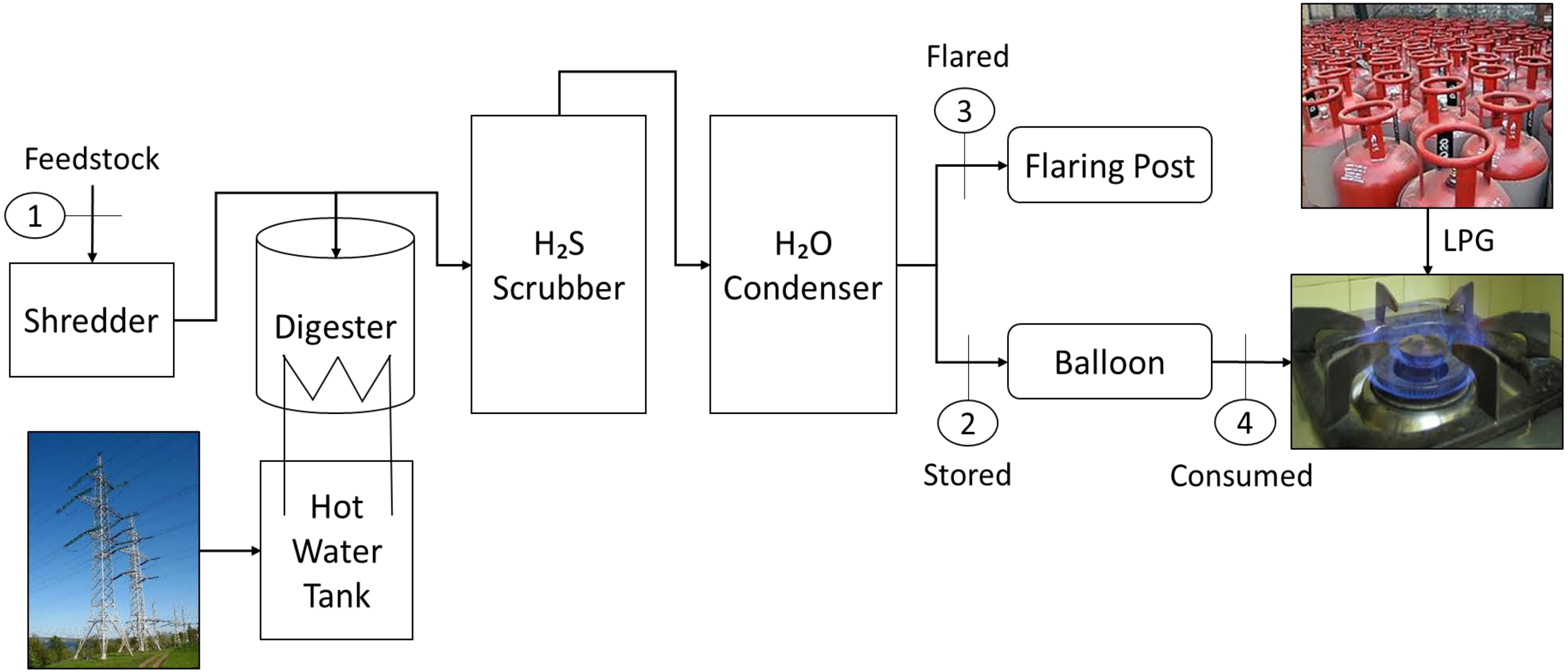
Aim & Methodology

Aim:

Investigate how **first order models** can be used with **plant data** to improve **system control** by balancing **conflicting objectives**

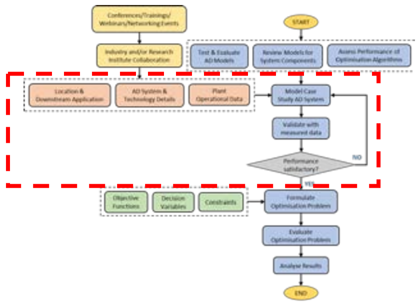


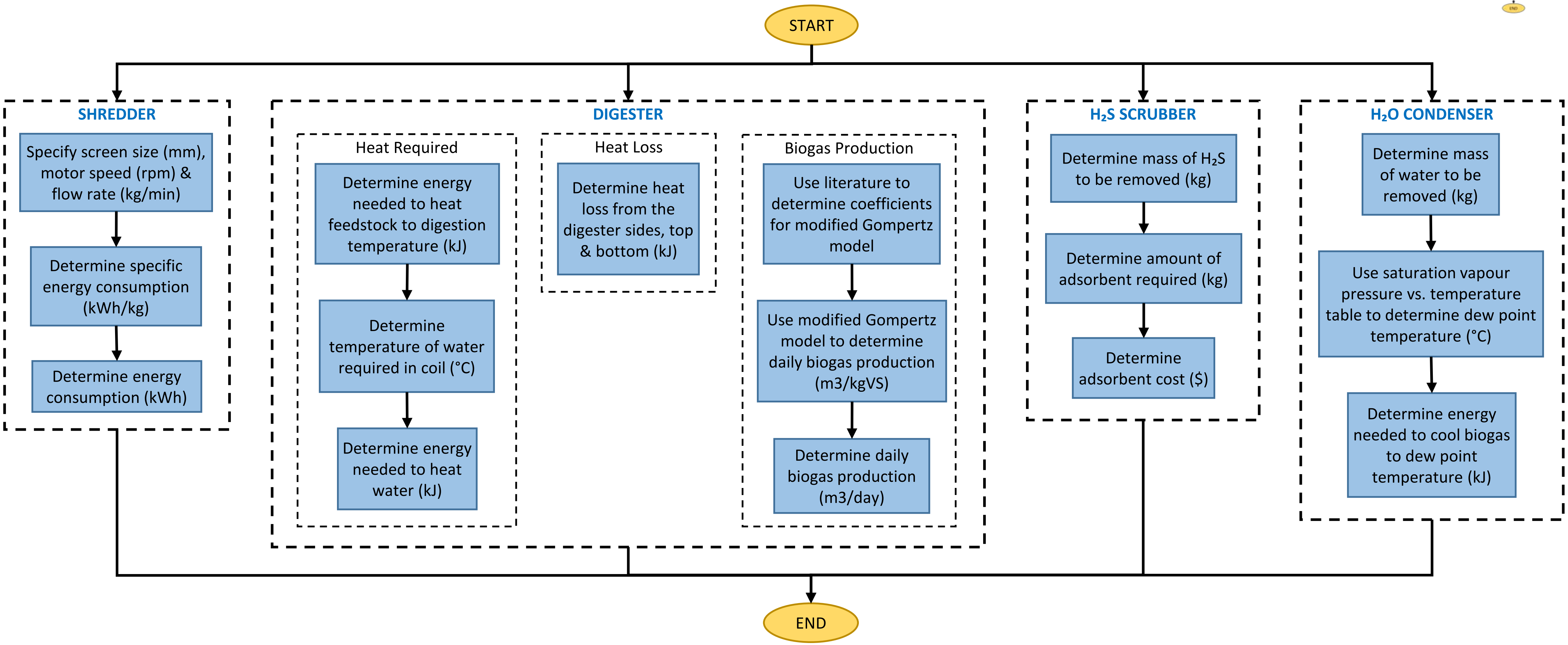
Case Study

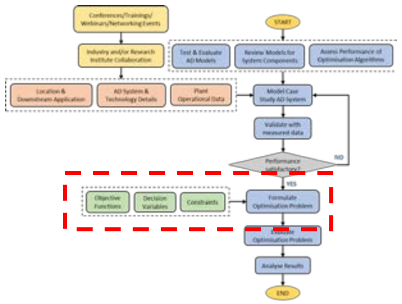


Feedstock
1
Shredder
Digester
Hot
Water
Tank
H_2S
Scrubber
H_2O
Condenser
Flared
3
Flaring Post
Balloon
2
Stored
4
Consumed
LPG

Component Models



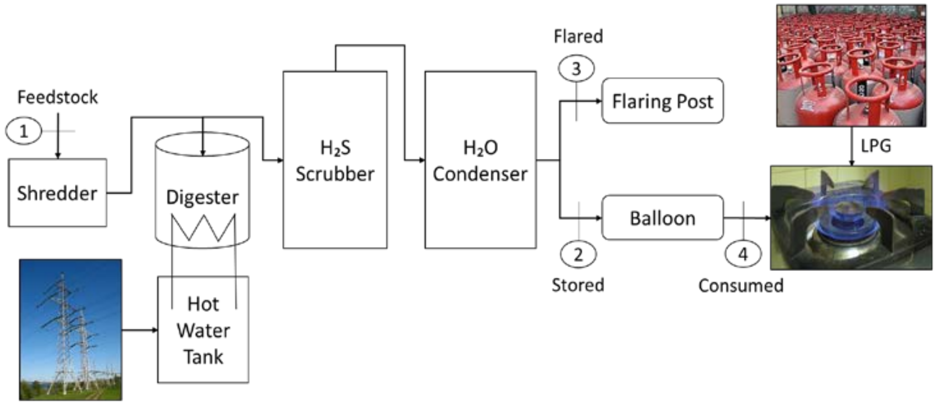




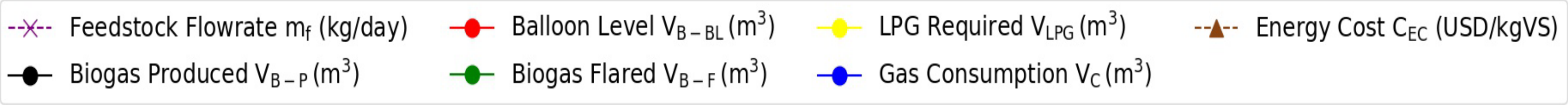
Optimisation Problem

- Scenario 1
  - Min. unmet demand (m^3)
  - Min. biogas flared (m^3)
- Scenario 2
  - Min. unmet demand (m^3)
  - Min. biogas flared (m^3)
  - Min. energy cost ($/kgVS)
- Optimisation Solver
  - NSGA II (Python)

$$C_{EC} = \left(\left(\left(E_{shred} + \frac{(E_{heatwater} + E_{loss} + E_{condenser})}{(1000 \times 3.6)}\right) \times C_{elec}\right) + C_{H2S}\right) \Big/ (m_f \times VS)$$

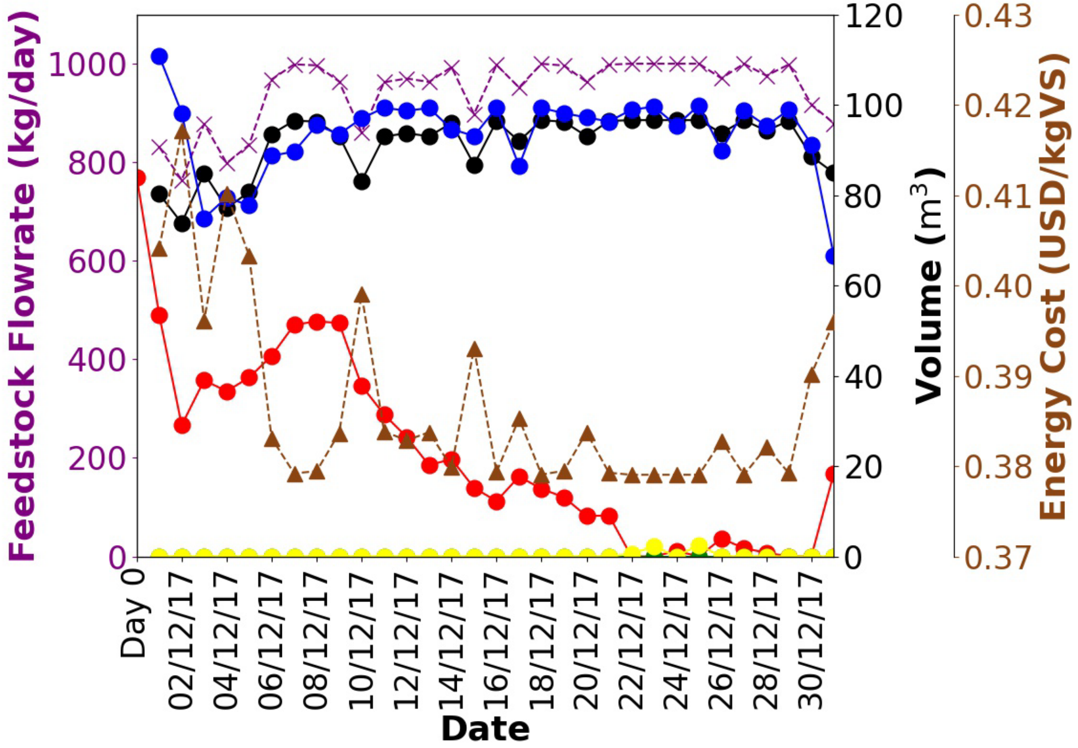


Optimisation Scenarios



Min. unmet demand (m^3)

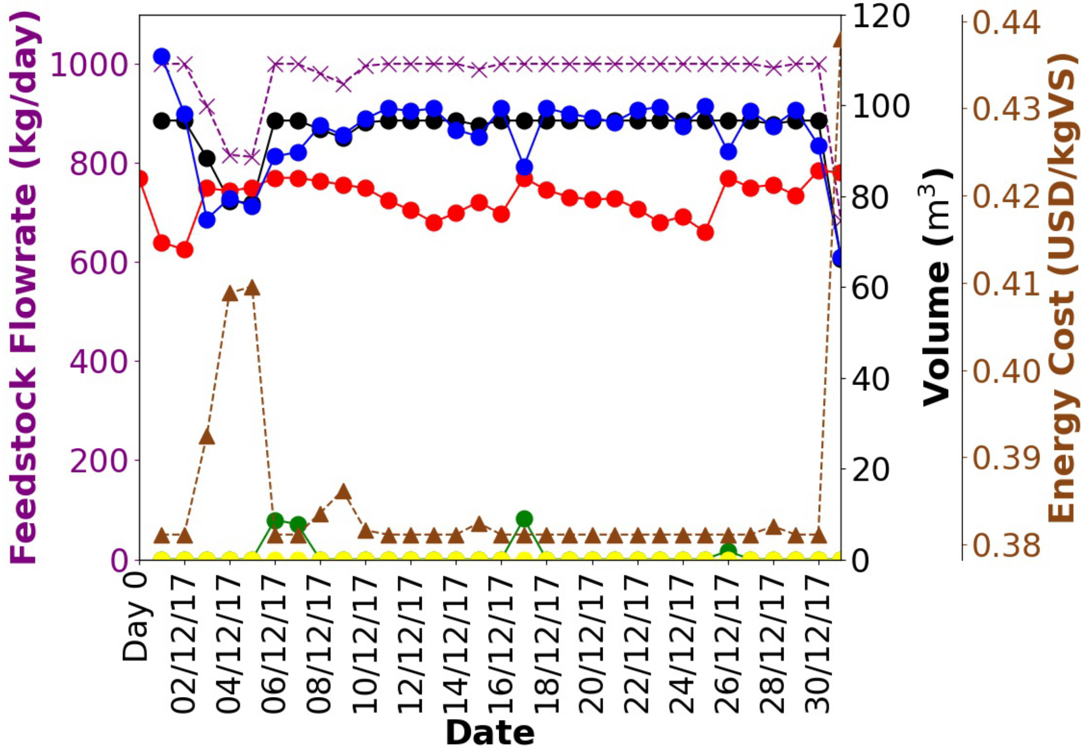
Min. biogas flared (m^3)



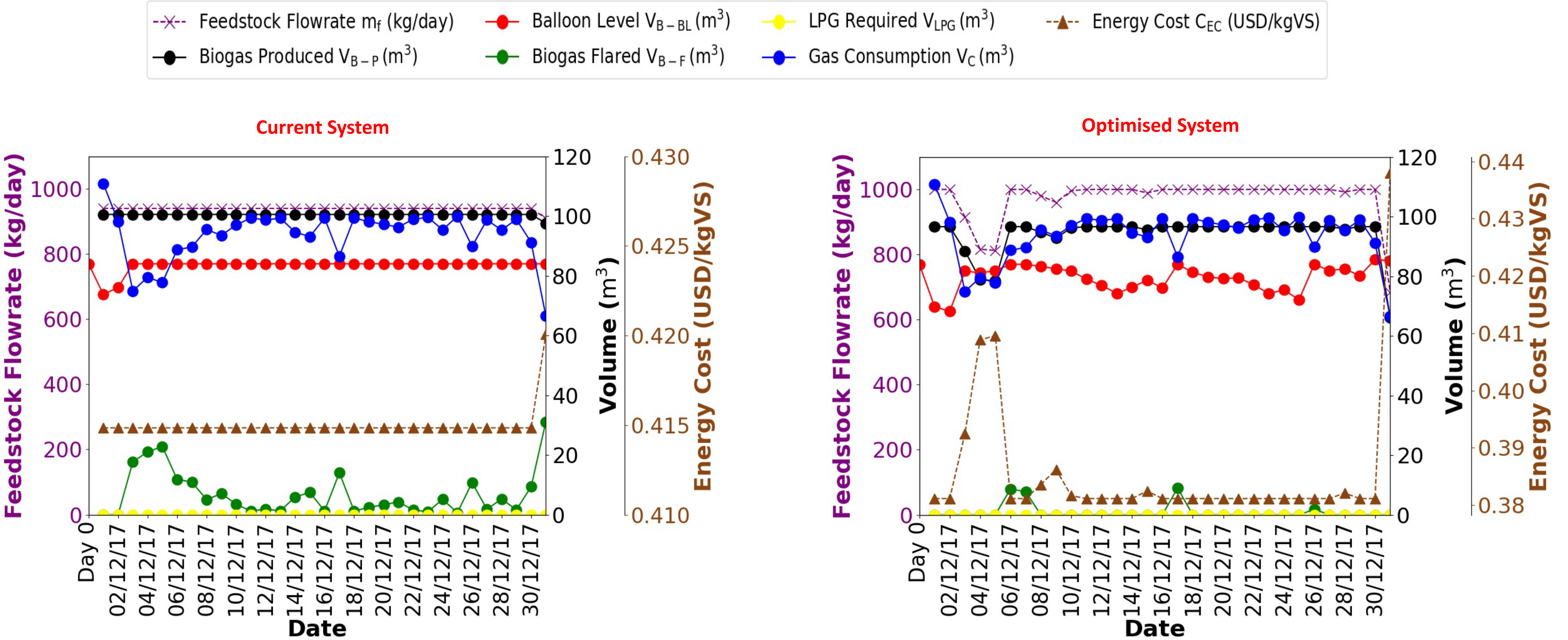
Min. unmet demand (m^3)

Min. biogas flared (m^3)

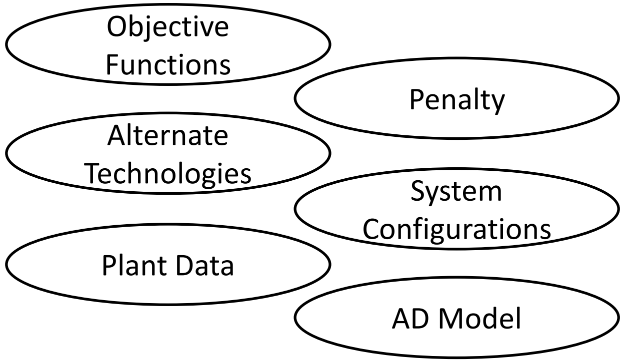
Min. energy cost (\$/kgVS)



Current vs. Optimised System



Conclusions & Future Work



- Optimisation
  - Add weightings to objective functions;
  - Assign a environmental penalty to flaring biogas;
  - Components altered &/or sized differently & different system configurations e.g.
    - Alternate pre and post treatment technologies;
    - Passing biogas through CHP unit to generate electricity & heat;
    - Additional objective functions & decision variables.
- AD Model
  - Modified Gompertz model not suitable for digesters operating in continuous mode
  - Plant data for entire year & values of digester operational variables (pH, temperature etc.)

Thank You!

Questions?