

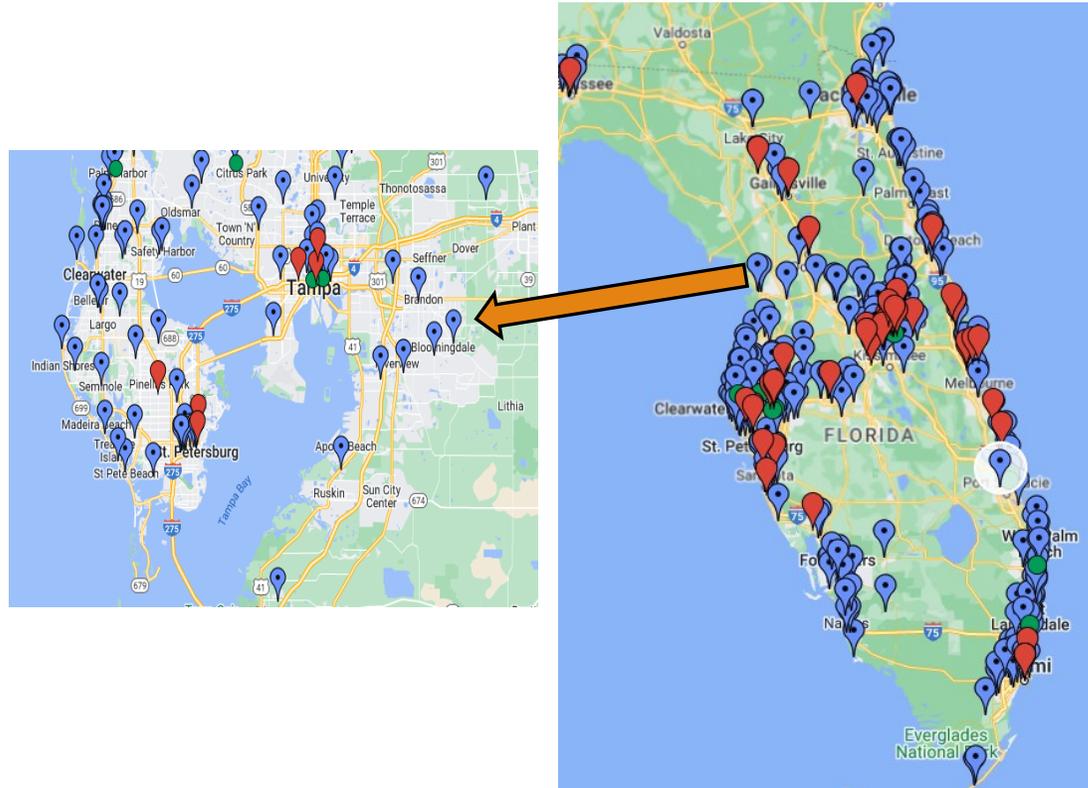


Anaerobic co-digestion of craft brewery waste using hops and yeast

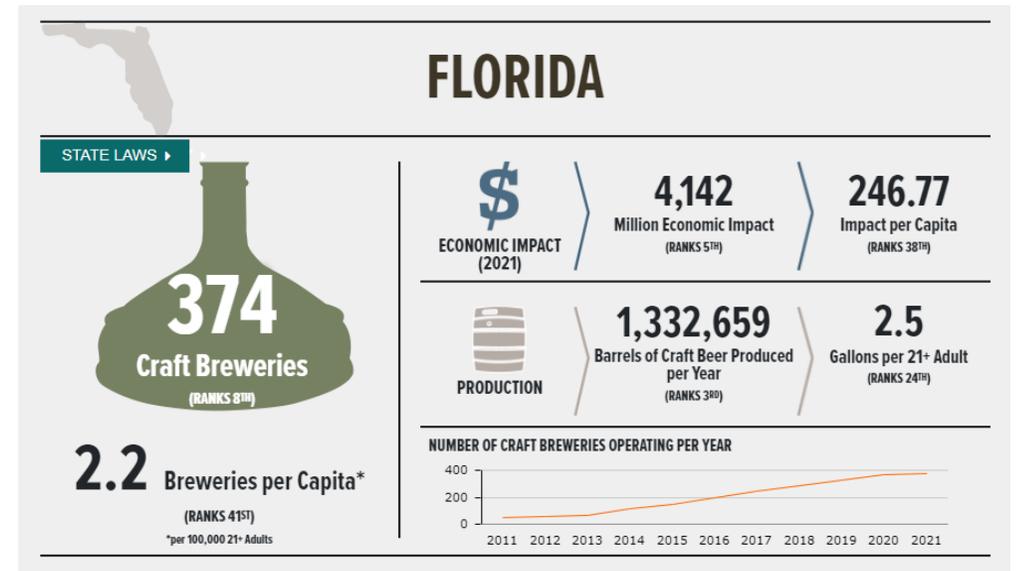
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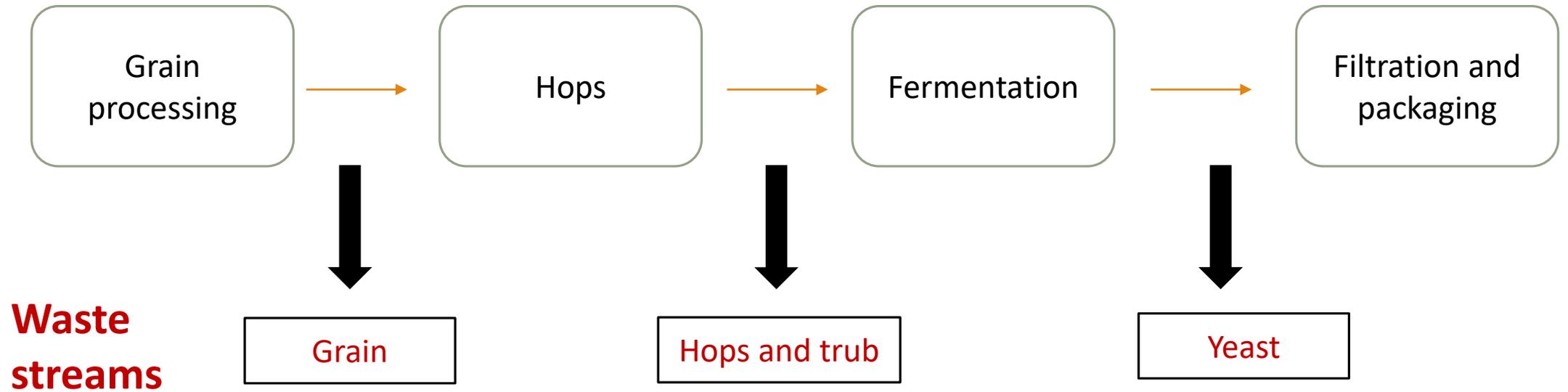
Craft Breweries in Florida



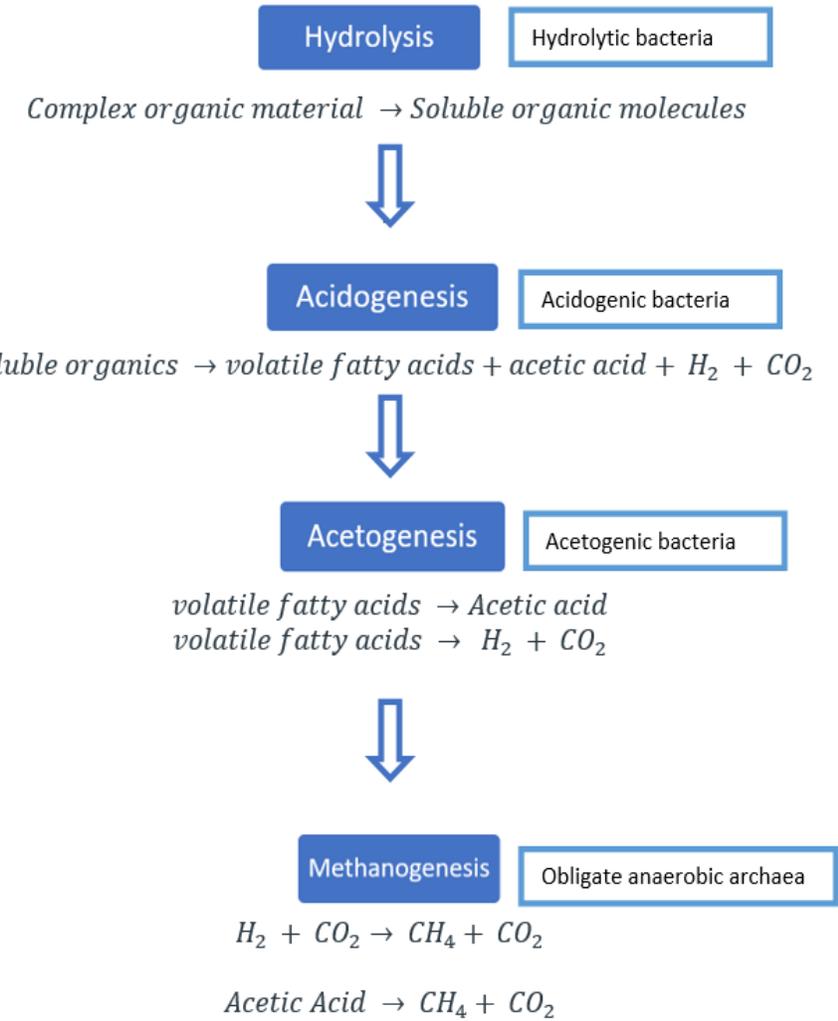
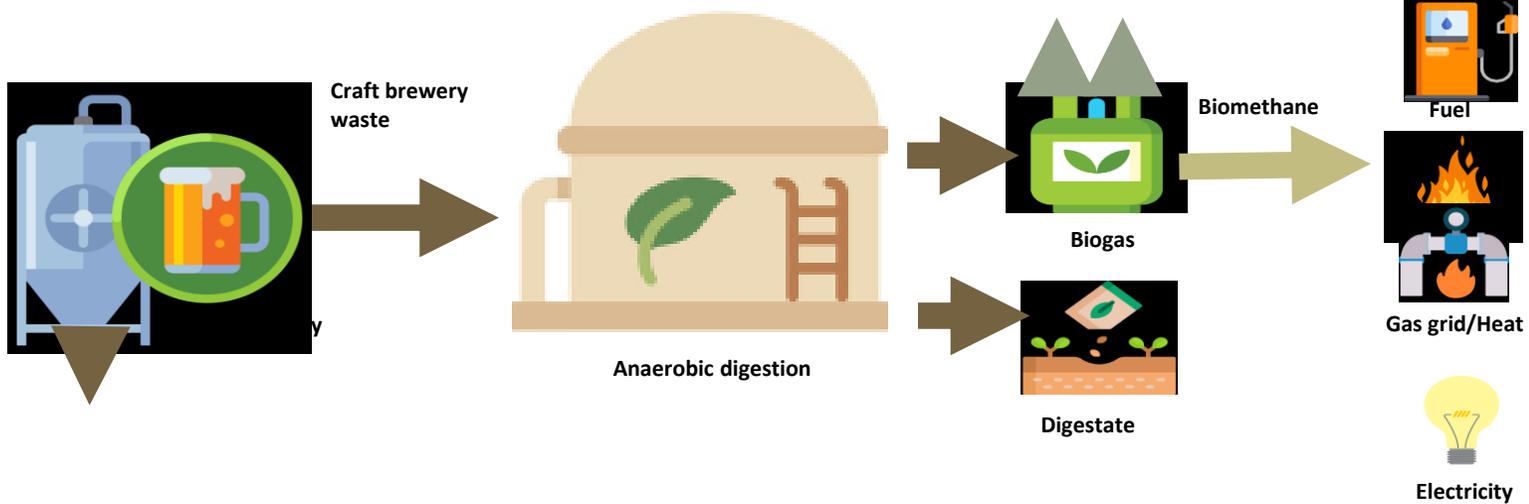
Craft breweries are defined as breweries producing less than 6 million barrels of beer annually



The brewing process



Anaerobic digestion



Motivation

- High strength waste
 - High organic matter
- Waste surcharges
 - 16 to 22% of net utility expenses
- Research Gaps
 - Effects of hop antimicrobial properties on anaerobic digestion process
 - Costs and benefits for craft brewers

Project Activities



Craft brewery waste management



Resource Recovery potential



Economic analysis



Cross campus collaborations

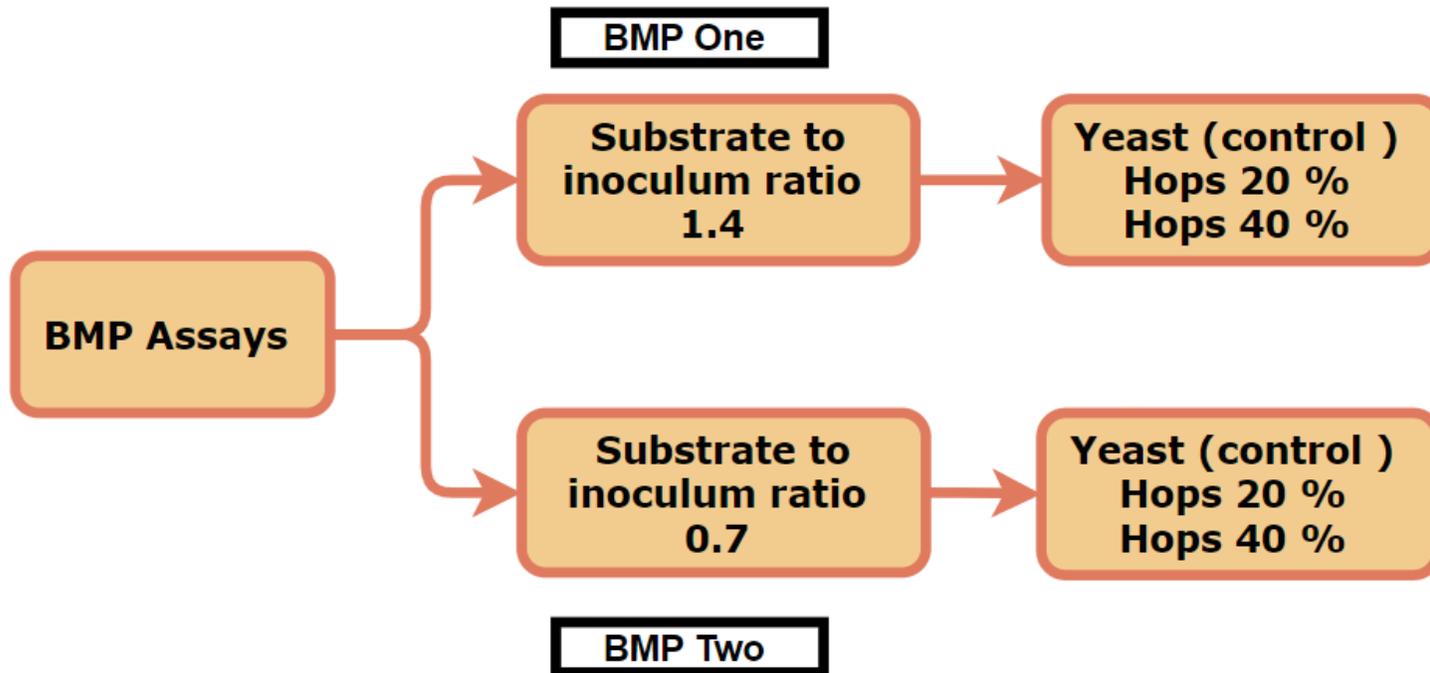


Education and outreach

Methodology

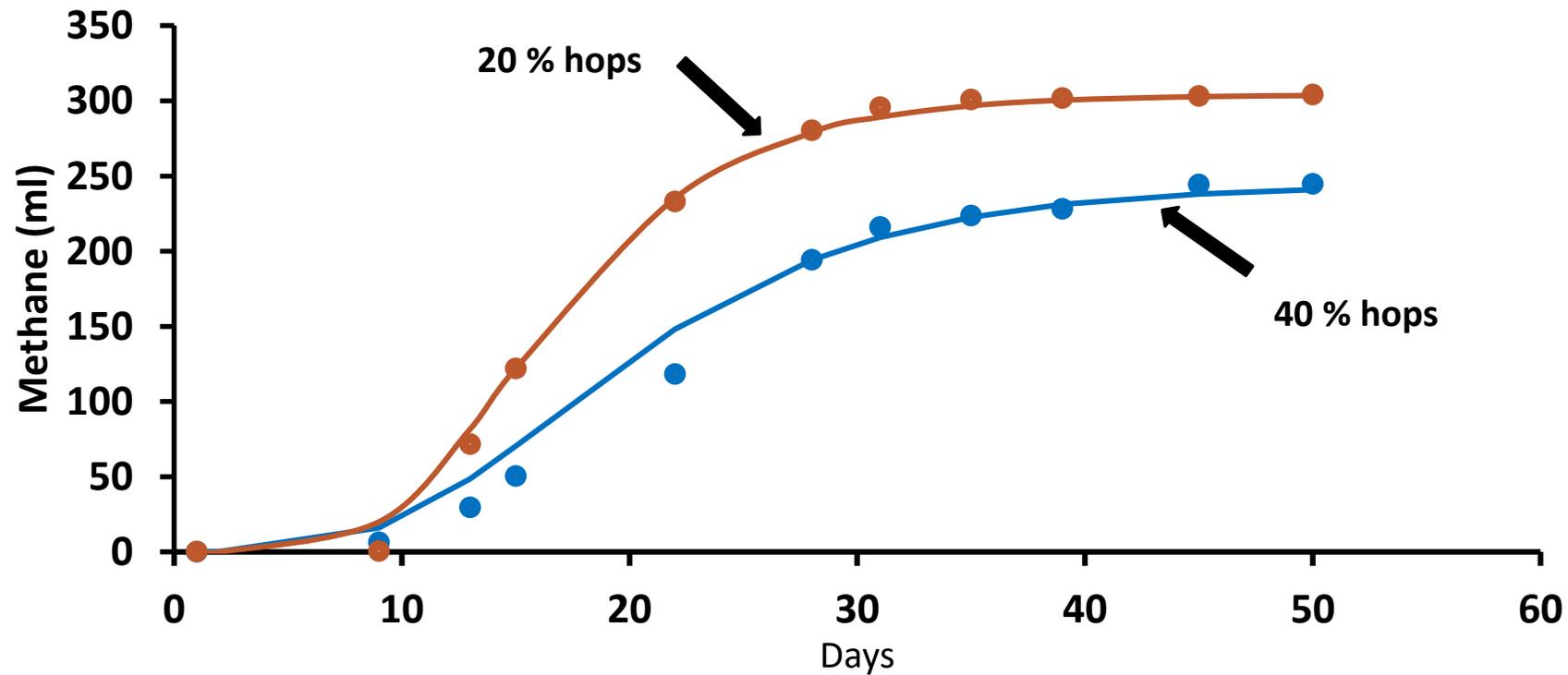


Biomethane potential (BMP) assays



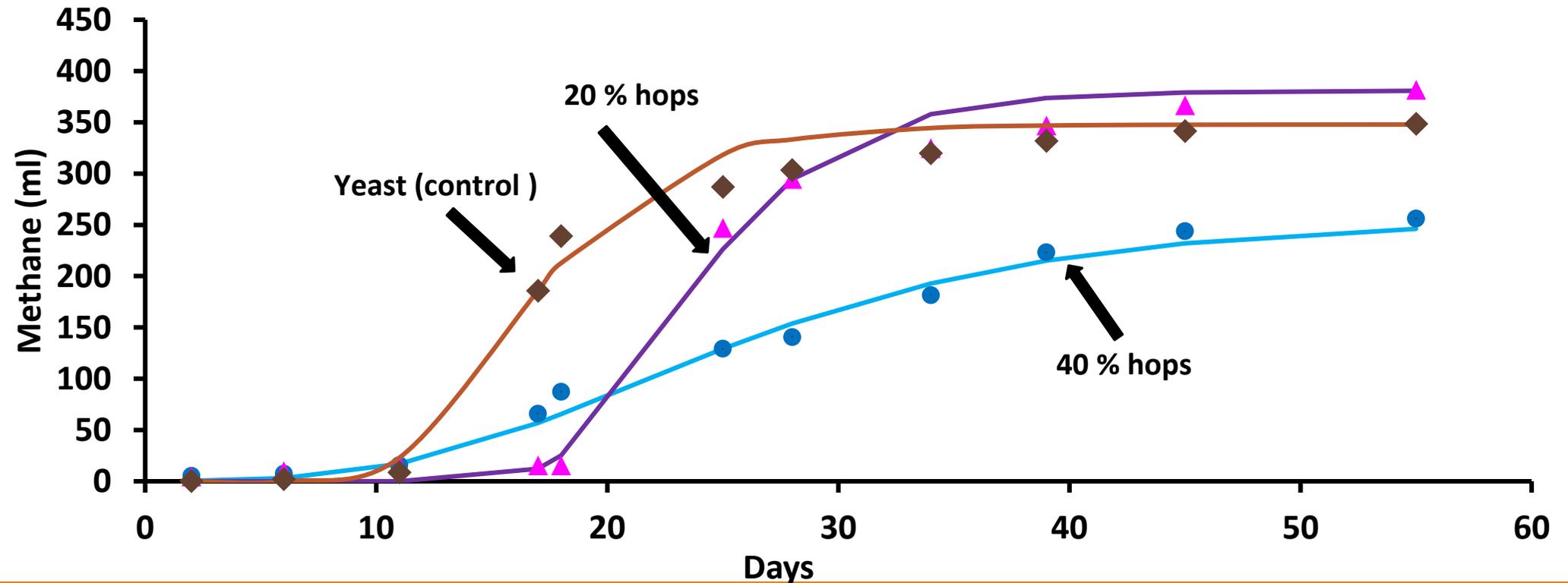
Effect of hop dosage at high substrate to inoculum ratio

Cumulative Methane Production and Gompertz Model Fit



Effect of hop dosage at low substrate to inoculum ratio

Cumulative Methane Production and Gompertz Model Fit

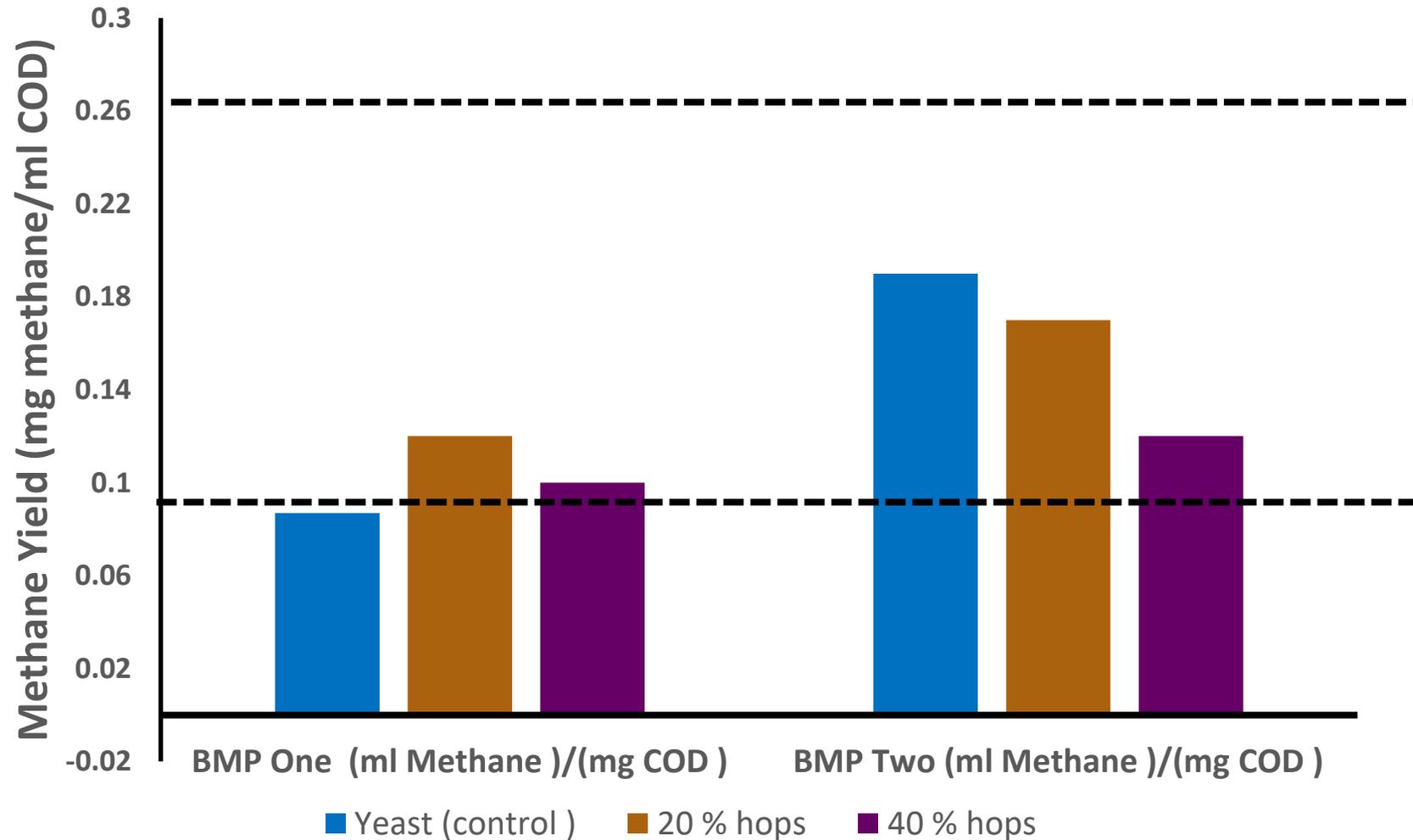


Cumulative methane yields

Literature values for methane yield of brewery waste are reported between 0.1 - 0.3

$$\frac{\text{ml } CH_4}{\text{mg } COD}$$

Methane yields obtained from BMPs

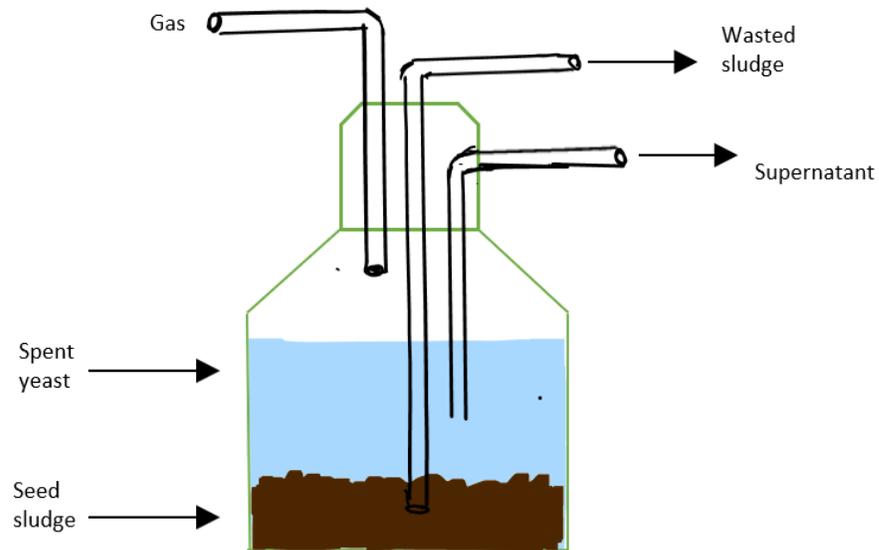


Anaerobic Sequencing Batch Reactors (ASBR)

Organic Loading Rate = $1000 \frac{mg\ COD}{L\ Day}$

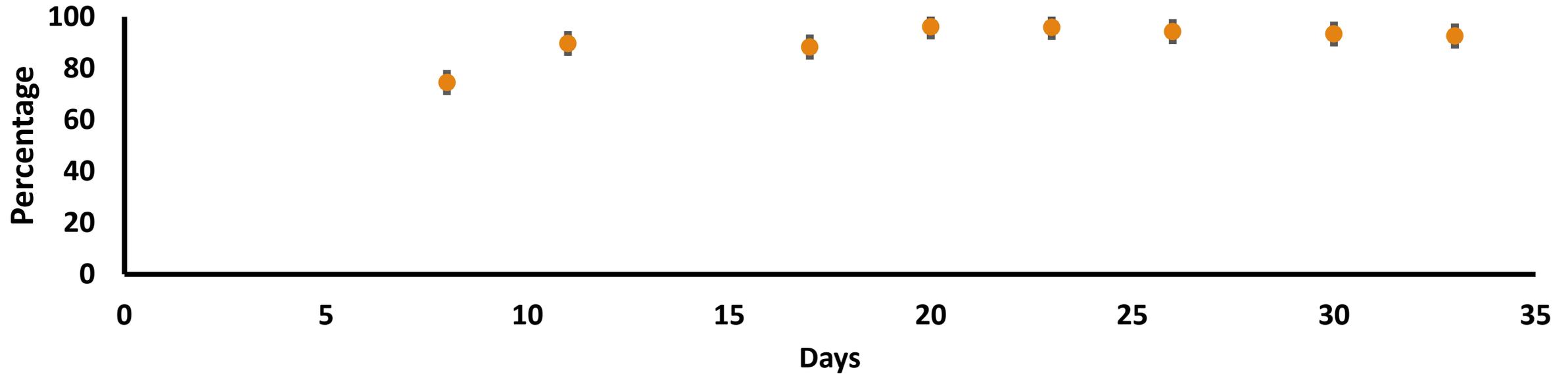
Hydraulic Retention time = 30 days

Solids Retention Time > 30 days

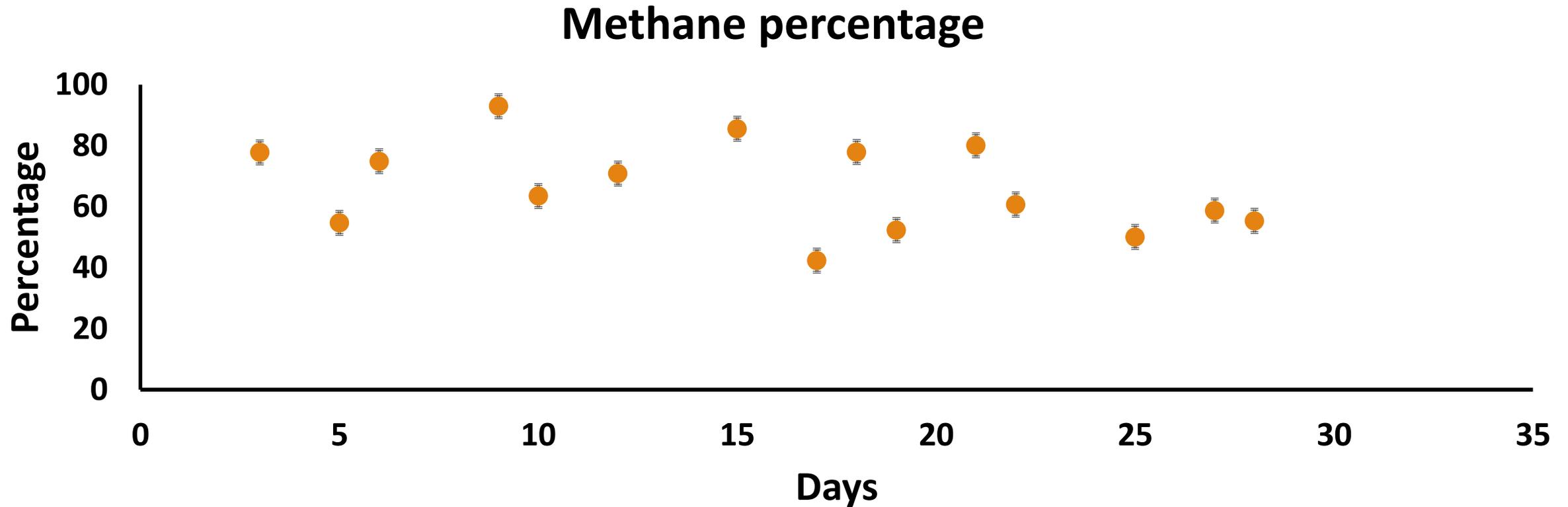


COD Degradation in ASBR of yeast waste

COD Degradation in ASBR Reactors

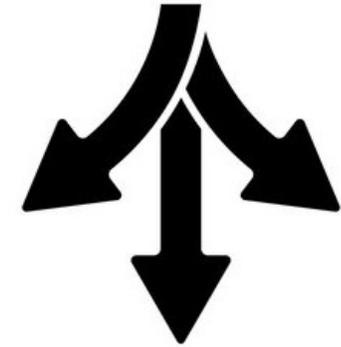


Methane percentage from ASBR of yeast waste

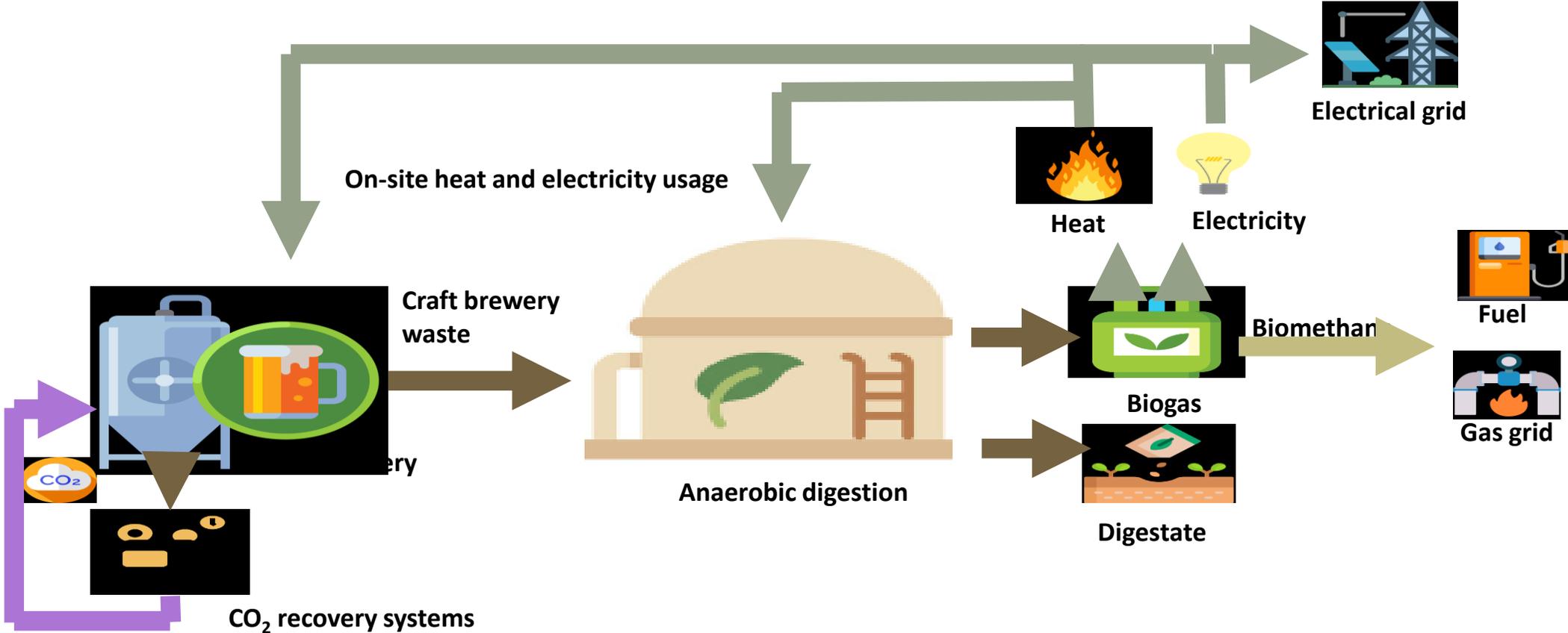


Economic analysis

Cost/benefit analysis of different
waste management scenarios
based on the brewery size.

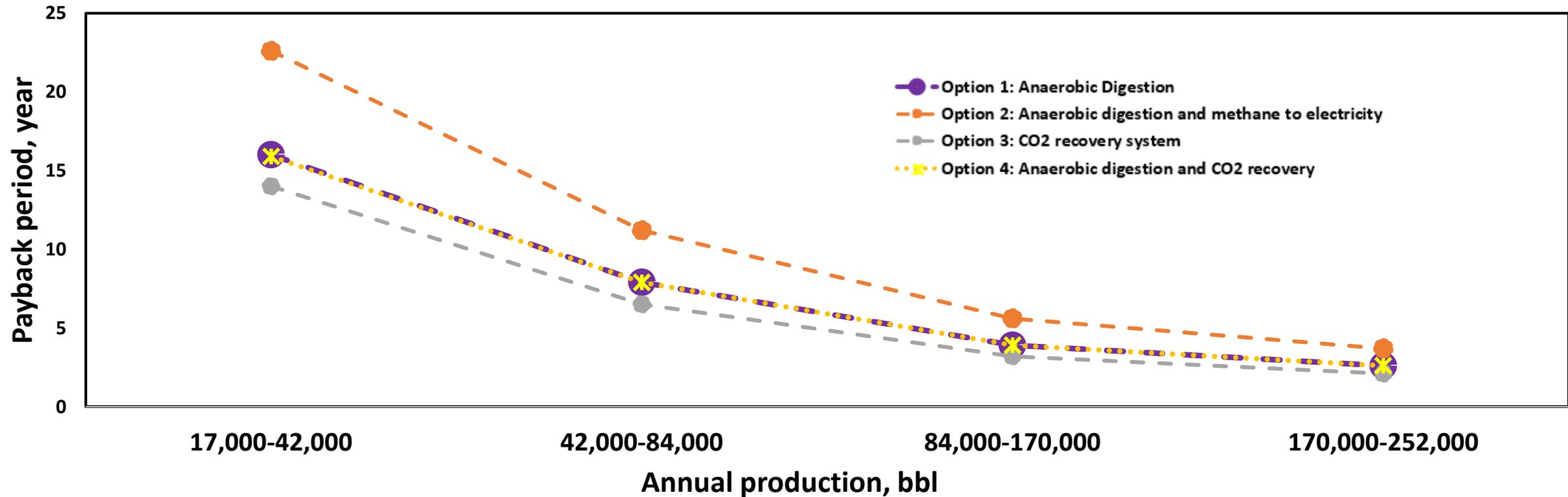


Economic analysis



Payback period vs. brewery size

Comparison of Payback Periods



Economically feasible for medium to larger sized breweries

Conclusions

- At low dosage, hops enhance methane production while at high dosage it is an inhibitor
- For medium sized craft breweries, use of AD to produce natural gas coupled with CO₂ recovery would require a payback period of about 16 years

Acknowledgements

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