# Iowa State University

## Department of Agricultural and Biosystems Engineering

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## Project Rationale and Goals

- Iowa has more than **2,000 swine farms** that could be sites for **profitable biogas production** [1]
- The **failure rate** of farm-based digesters has been as high as **50%**[2]. Recently, this rate has been closer to **25%**[3].
- Centralized digesters may **allow dedicated operations staff** to manage day-to-day tasks, reducing the farmers' management burden and **reducing digester abandonment**[4].
- **Goals:** Evaluate costs for swine manure and corn stover co-digestion systems at different levels of centralization and corn stover input
  - *Why add corn stover?* Co-digesting manure with crop residues can increase digester productivity[5].

## Methods

### Scenarios

1. Single farm-scale digester, no additional water added
2. Single farm-scale digester, water added to double digester volume
3. Single farm-scale digester, water added to double digester volume, upgrading and injection capital shared with four other equally-sized digesters (biogas transported 2.5 miles)
4. Centralized digester for 5 equally-sized farms (manure transported 2.5 miles from each farm)

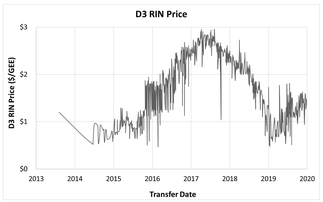
### Key Inputs

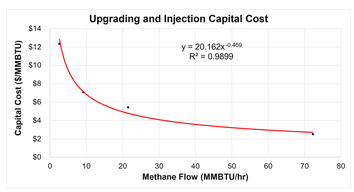
- Farm size
- Biogas $CH_4$ %
- Stover BMP**
- Interest
- Max solids loading
- Manure BMP
- Plant Life
- Transport distances
- Pipeline Cost
- Scaling exp
- Digestate value*
- Upgrading efficiency

**Digestate: Digester effluent, utilized as fertilizer  **BMP: Biological methane potential*

### RIN Value

- Value of Renewable Identification Numbers (RINs) were subtracted from production cost
- The value of D3 RINs is variable over time (see figure[6]). 2017-2020 average was utilized

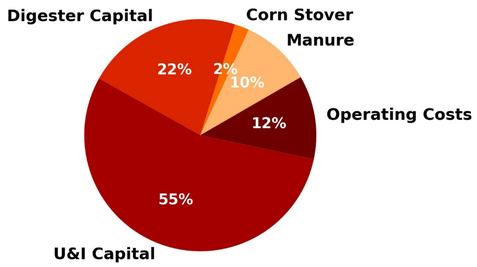


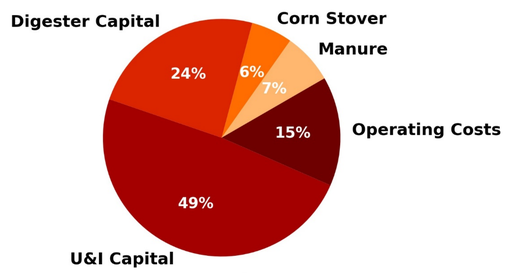

### Upgrading and Injection Capital Cost

- Equipment required to upgrade biogas to RNG quality and injected into pipeline. Adapted from [7]

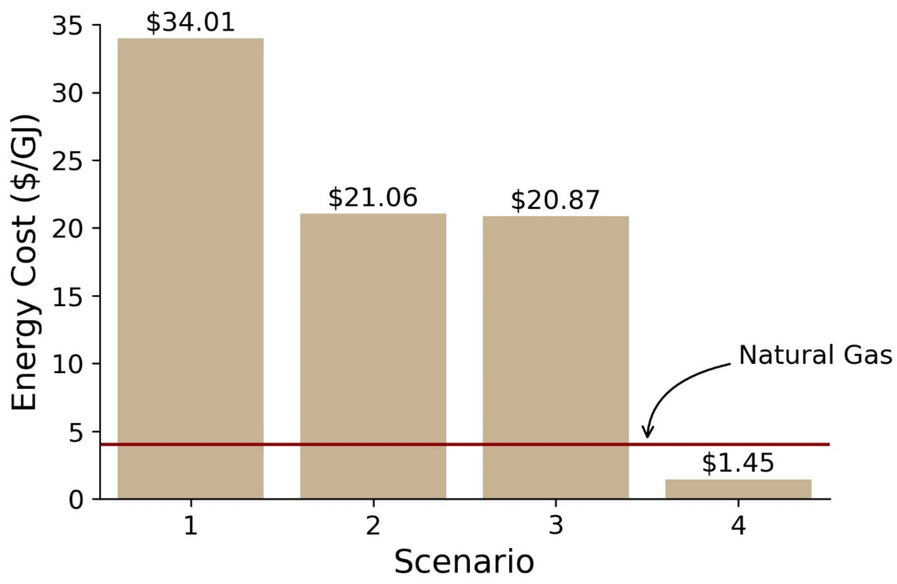
## Technoeconomic analysis finds **centralized** swine manure and corn stover co-digestion systems have an **economic advantage** over distributed systems

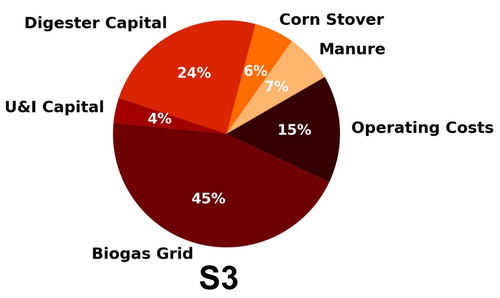



**S1**

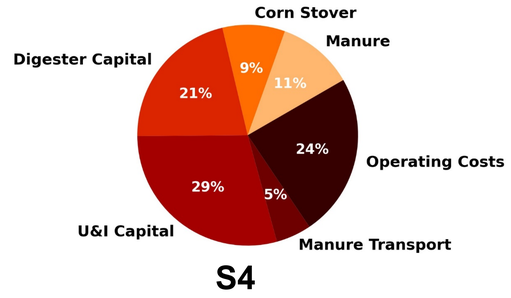



**S2**



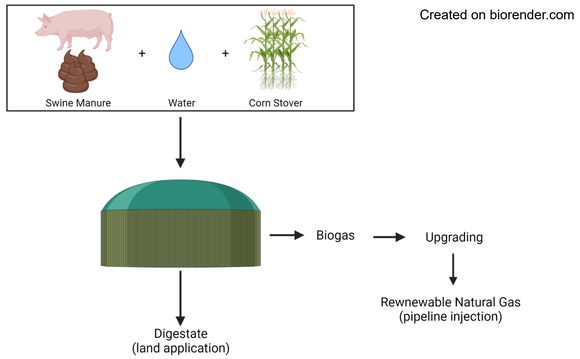




**S3**



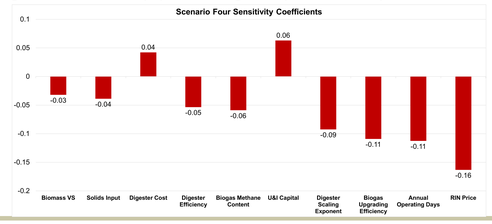

**S4**

Costs compared to 10-year average Iowa citygate natural gas price
U&I Capital = Capital costs associated with upgrading biogas to RNG and injecting RNG into pipeline




## Results

- **Water addition** to the digester allows for greater corn stover input, greater methane production, and **lower unit cost**
  - Higher corn stover input requires greater land area for digestate application
- Sharing an upgrading and injection point (S3) has a slight advantage over totally decentralized production (S2)
- Totally **centralized system** (S4) is **most economically completive** with natural gas
- Manure transportation distances greater than 7 miles per digester in S4 are no longer competitive with natural gas
- Final cost of S4 was **most sensitive to the RIN value**
  - Sensitivity coefficients shown in the figure are represented as (% change in final cost)/(% change in parameter)




## Conclusions

- A **centralized** swine manure and corn stover co-digestion **can be competitive with natural gas** prices in Iowa
- Without complete centralization, a shared biogas upgrading and injection point offers a slight advantage over totally decentralized production – lower pipeline prices increase this advantage
- Sufficiently **high RIN prices are required** to reach cost parity with natural gas

## References

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