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CAPE BRETON REGIONAL MUNICIPALITY

Design of an Anaerobic Digestion Process to Replace Current Composting Operations at CBRM

Introduction

The Cape Breton Regional Municipality (CBRM) proposed a Capstone project for Dalhousie University regarding the design of an anaerobic digestion process to replace the current operations at their composting facility in Sydney, Nova Scotia. The current facility was built in 2008 to process a maximum of 12 000 tonnes of organics per year. Since then, there has been a large community uptake in the composting program. Problems with the current facility are that:

- It is too small to process the current compost demand
- The untreated compost is releasing odours

Anaerobic digestion (AD) is a popular alternative to composting because it:

- Reduces greenhouse gas emissions
- Generates renewable energy that reduces the use of fossil fuels

Design Process and Results

Biogas Production Laboratory Testing and Modeling

Figure 1. Lab setup.

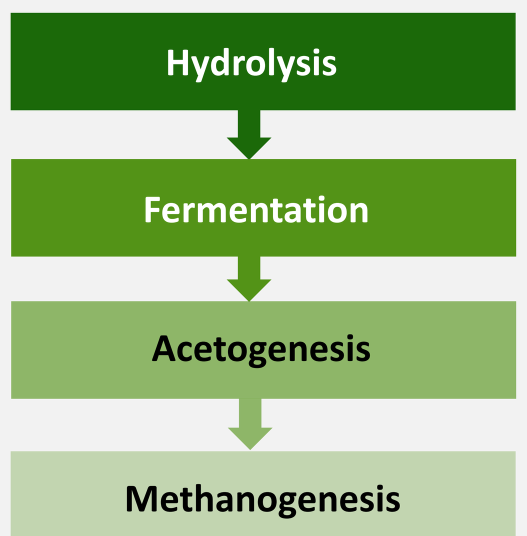

Figure 2. AD reaction scheme.

Table 1. Biogas production from various methods.

Approach	Daily (m^3 biogas)	Yearly (m^3 biogas)
Model	2574	939 510
Laboratory	2565	1 054 810
Literature	2247	820 000

Biogas Upgrading Process

Table 2. Biogas composition before and after upgrading.

Compound	Inlet (mol fraction)	Outlet (mol fraction)
CH_4	0.55	0.975
CO_2	0.42	0.019
H_2O	0.027	0.0063
H_2S	0.0033	0.0001

Details of Design

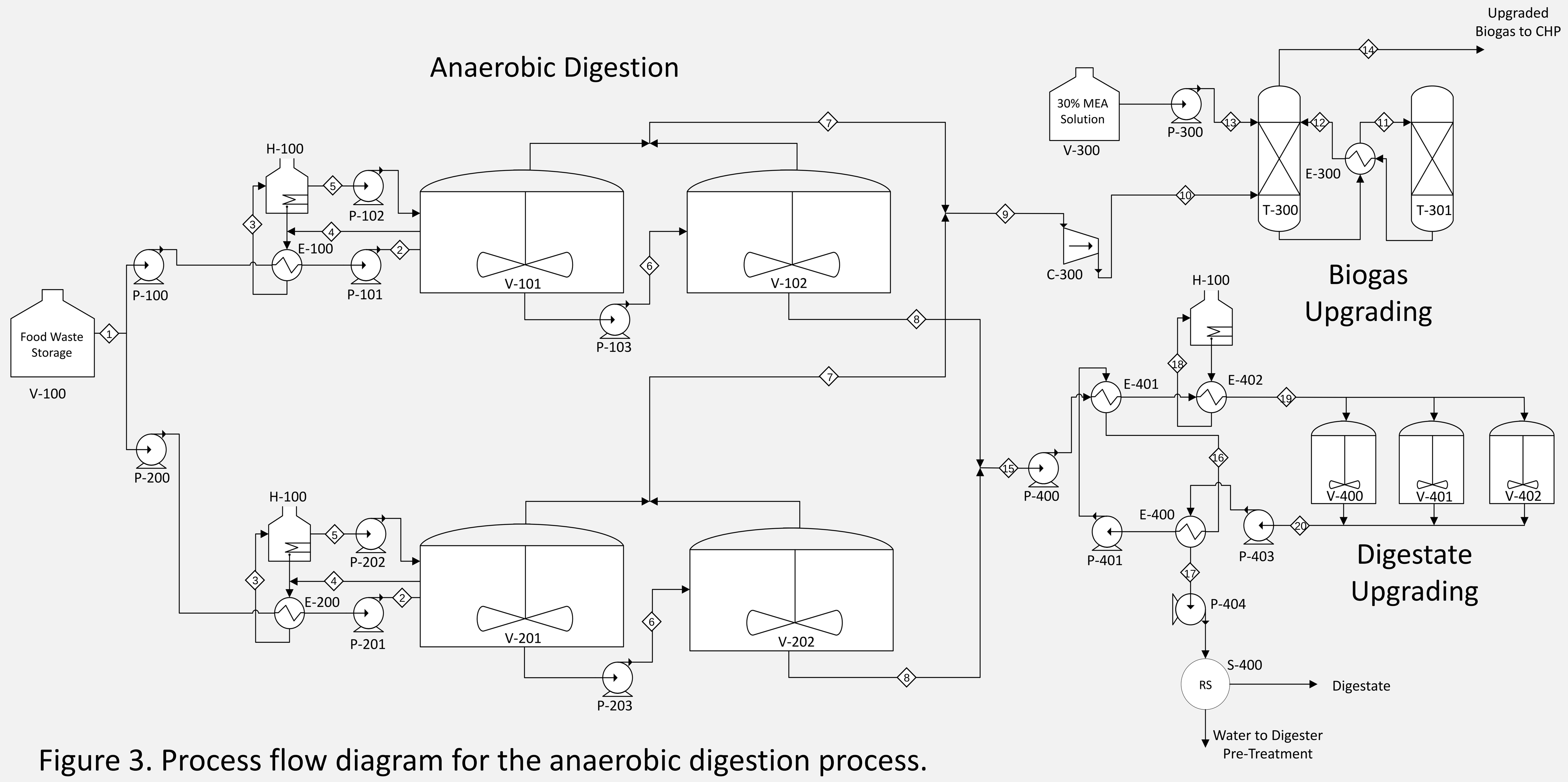

Figure 3. Process flow diagram for the anaerobic digestion process.

Anaerobic Digestion Process

The anaerobic digestion design features two-stage digesters in parallel, operating continuously. The two-stage design allows for optimal digester conditions for the reaction scheme to occur, increasing biogas yield. The food waste inlet was assumed to be pre-treated and mixed with water to 10 wt. % solids. The heating fluid (50 wt. % glycol-water) is used in the heat exchangers and heating coils to obtain a mesophilic temperature of 37°C (2). The inlet flowrate was determined to be 275 m^3/day to each digester (2). Each digester is 1000 m^3 and the retention time is 6.5 days per digester.

Biogas Upgrading Process

The biogas produced from all digesters is collected (7) and mixed into one inlet feed of 4.98 kmol/h and 55 mol % CH_4 (9). This enters the absorption column (10) where CO_2 is absorbed by 30 wt. % MEA solution. The CO_2 rich solution is heated (11) and enters the desorption column where CO_2 is purged. The lean MEA solution is then cooled and recycled back to the absorption column (12). The absorption column is a packed bed column with a height of 17.6 m and diameter of 0.2 m. The packed bed height is 3 m with 25 mm metal Pall ring packing. The resulting upgraded biogas exits at 2.81 kmol/h containing 97.5 mol % CH_4 (14).

Digestate Upgrading Process

The digestate from all digesters is collected (8) and mixed into one stream with a flow of 550 m^3/day (15). It is then heated to 70°C . The digestate enters one of three 24 m^3 holding tanks where the temperature is maintained for one hour to pasteurize. The pasteurized digestate is pumped through the final heat exchanger to cool (20). The recovered heat from this heat exchanger is circulated back to the first heat exchanger. The pasteurized digestate is pumped to a rotary separator, where the water is separated from the digestate (17). The recovered water is recycled to the feed pre-treatment.

Expected Energy Production and Economics

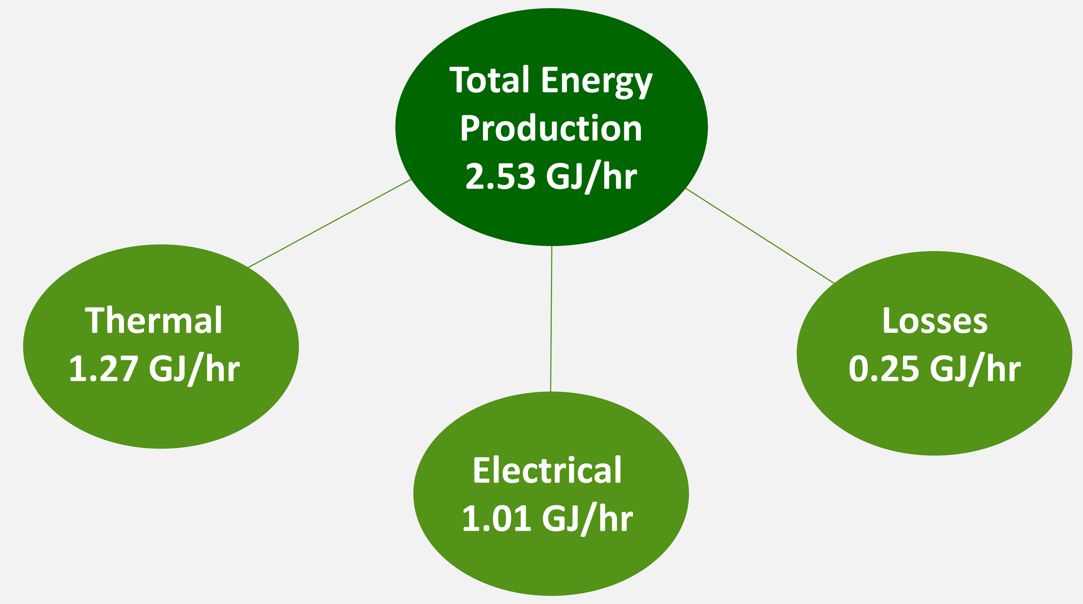

Figure 4. Expected energy production.

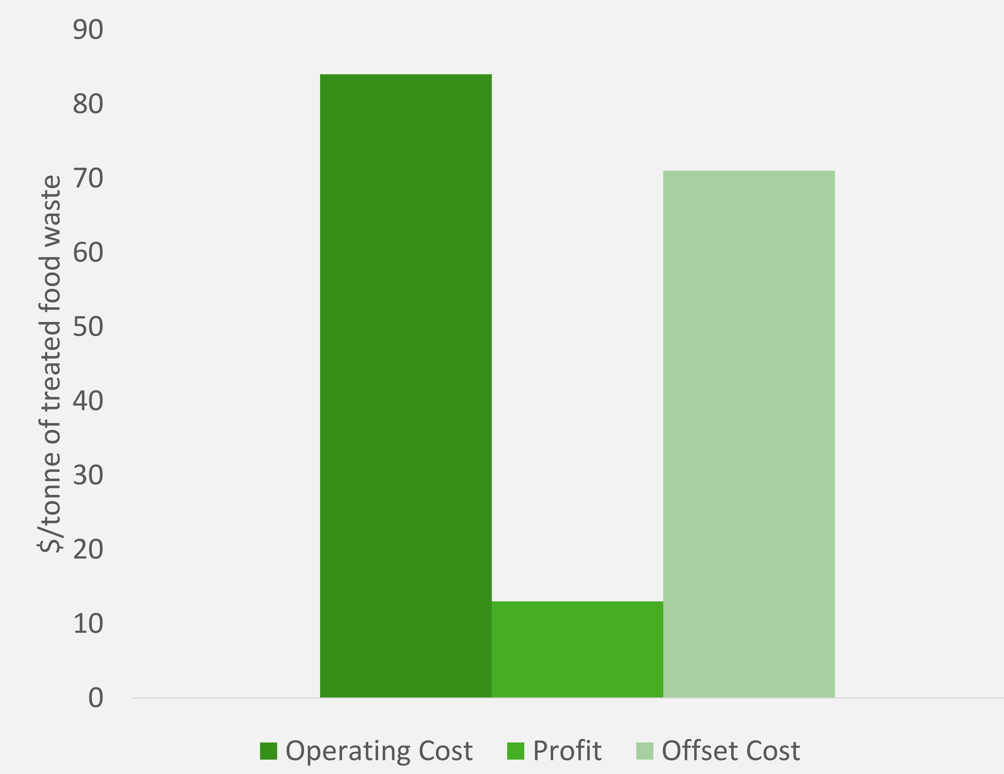

Figure 5. Operating costs and profit per tonne.

Conclusion and Recommendations

- This design project showed the feasibility of using anaerobic digestion to solve the current problems at CBRM and presented a design which may be implemented after further optimization.
- Market research should be performed to determine if the digestate can be sold.
- Further BMP lab testing should be done to confirm the expected biogas production.
- Detailed design of auxiliary equipment and detailed economics should also be completed.

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