CRAFT BREWERY CARBON DIOXIDE RECOVERY SYSTEM

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Biological Engineering, Sustainability Minor

THE PROBLEM

The use of carbon dioxide during carbonation is an essential and expensive portion of the brewing process. This project explores the idea of recovering CO_2 from the fermentation process for use during carbonation. This allows the brewery the opportunity to reduce the current purchasing costs of compressed carbon dioxide, while also reducing the amount of carbon dioxide the brewery emits into the atmosphere.

THE PROJECT

The brewery consumes a 5000 standard cubic feet (scf) tank of CO_2 per week for all uses (carbonation, purging/cleaning, inefficiencies, and losses) throughout the brewery. This is equivalent to 280.33 kilograms (kg) CO_2 used per week. It was assumed the brewery produces 200 barrels (bbl) of beer a week. Based on the alcohol percentage of the beer, it was calculated that 1196.88 kg CO_2 were produced during fermentation. The fermentation temperature and the solubility of CO_2 in beer determines the amount dissolved into the beer; 75.83 kg CO_2 dissolves per week. The emitted CO_2 is equal to the produced CO_2 minus the dissolved CO_2 which is 1121.05 kg CO_2 per week. Using this Information, a system that captures, cleans, and stores the emitted CO_2 was designed.

Process	kg CO_2 /week
Carbonation	-118.04
Purging/Inefficiencies/ Losses	-162.29
Total Used	-280.33
Produced During Fermentation	+1196.88
Dissolved into Beer	-75.83
Emitted into Atmosphere	+1121.05

ACKNOWLEDGEMENTS

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FINAL DESIGN

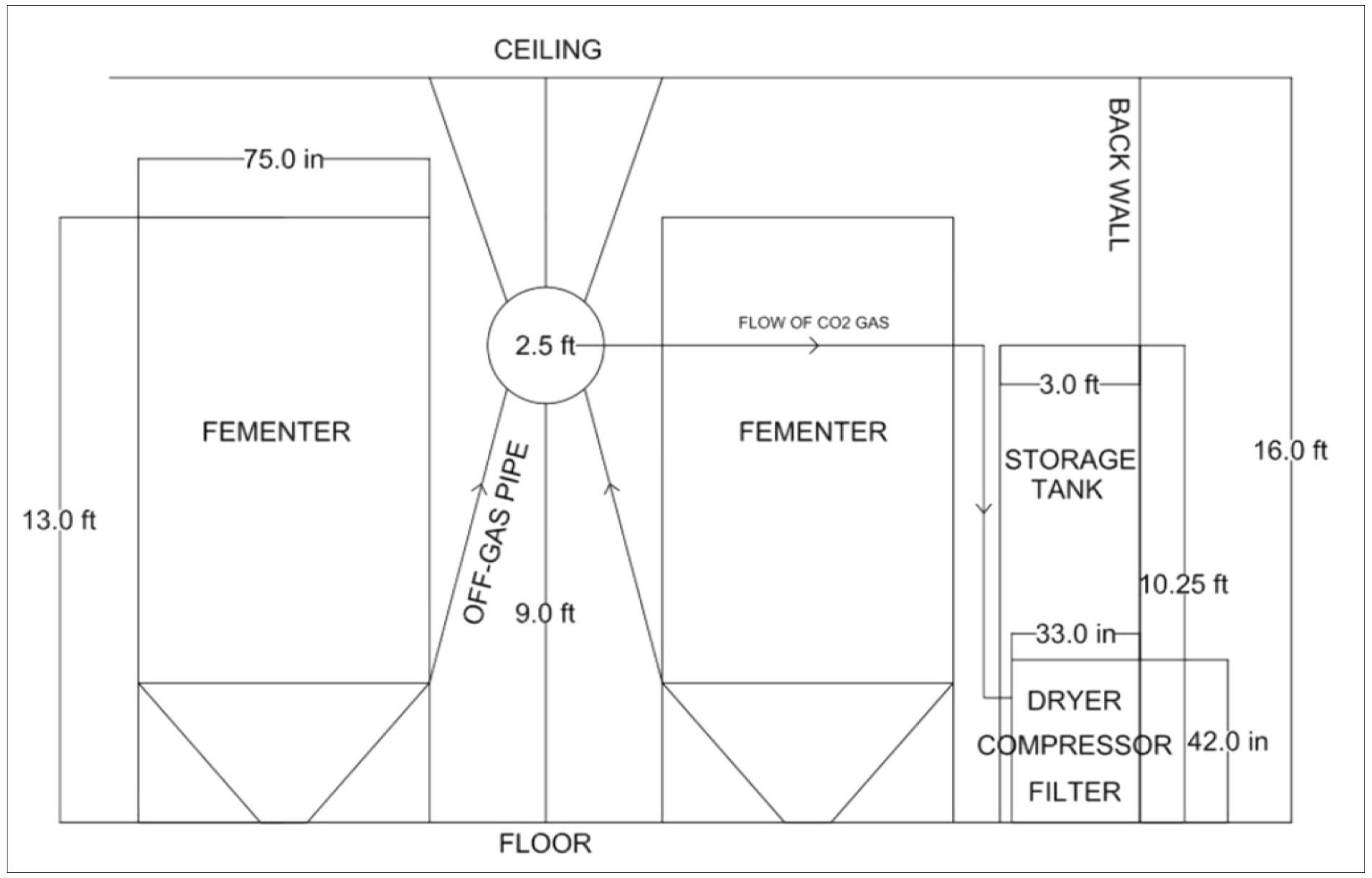

Figure 1. Designed System Side View

SYSTEM OVERVIEW

The final design consists of a storage bag that captures off-gas via hoses from the fermentation tanks. The system connects to up to three fermentation tanks and captures gas for a 60 hour time period. The system is designed to start after the first 24 hours of fermentation. This is because most impurities are released during this time, maximizing the lifespan of the filter used later in the system. The stored carbon dioxide is then piped into a dryer in order to remove all moisture from the gas. After being dried, the gas is filtered in order to remove all remaining impurities. Once filtered, the carbon dioxide is compressed and stored in a pressurized tank. At this point, the system is complete and carbon dioxide is ready to be used throughout the brewery. Figure 1 and Figure 2 are a side and top view of the final design, respectively. While this design is specific to this craft brewery, it is indented to be altered for other breweries.

ENGINEERING DESIGN

The sizing of the system's components was completed using various knowledge and applications of engineering. The storage bag was sized based on the incoming gas flow rates and the corresponding carbon dioxide collection periods. Sizing the pipes that transported carbon dioxide from storage to the dryer and compressor, the use of Bernoulli's equation was necessary. Bernoulli's equation can be seen below:

$$W_{1-2} = F_{1-2} = F_{entry} + F_{pipe} + F_{elbow} + F_{dryer}$$

Bernoulli's equation is used for modeling fluid systems and determining friction loss or pressure drop in a system. Other equations that are derived from Bernoulli's were used in order to determine friction elsewhere in the system. The compressor was sized so that it could match the incoming maximum flow rate of the gas. The final storage tanks were sized in order to accommodate two to three days of compressed carbon dioxide. This volume was found calculated using the Ideal Gas Law.

SUSTAINABILITY

Reclaiming CO_2 in the brewing process reduces the negative effect the brewery has on natural systems as it cuts down on greenhouse gases that would otherwise be dispersed into the atmosphere. This system is estimated to reduce the brewery's CO_2 emissions from fermentation by 94%. This system has a positive impact on the built system for the same reason. It is reducing the carbon footprint of the business and therefore leaving less of a negative impact. Overall, this proposed design system would be beneficial to craft breweries, as well as the environment and those impacted by it.

The Sustainability Minor and all of the associated curriculum has opened our eyes to ways we can better this community and the entire world. We will forever make more conscientious decisions in how we design future engineering projects and take into account how these will impact the environment and people around us.

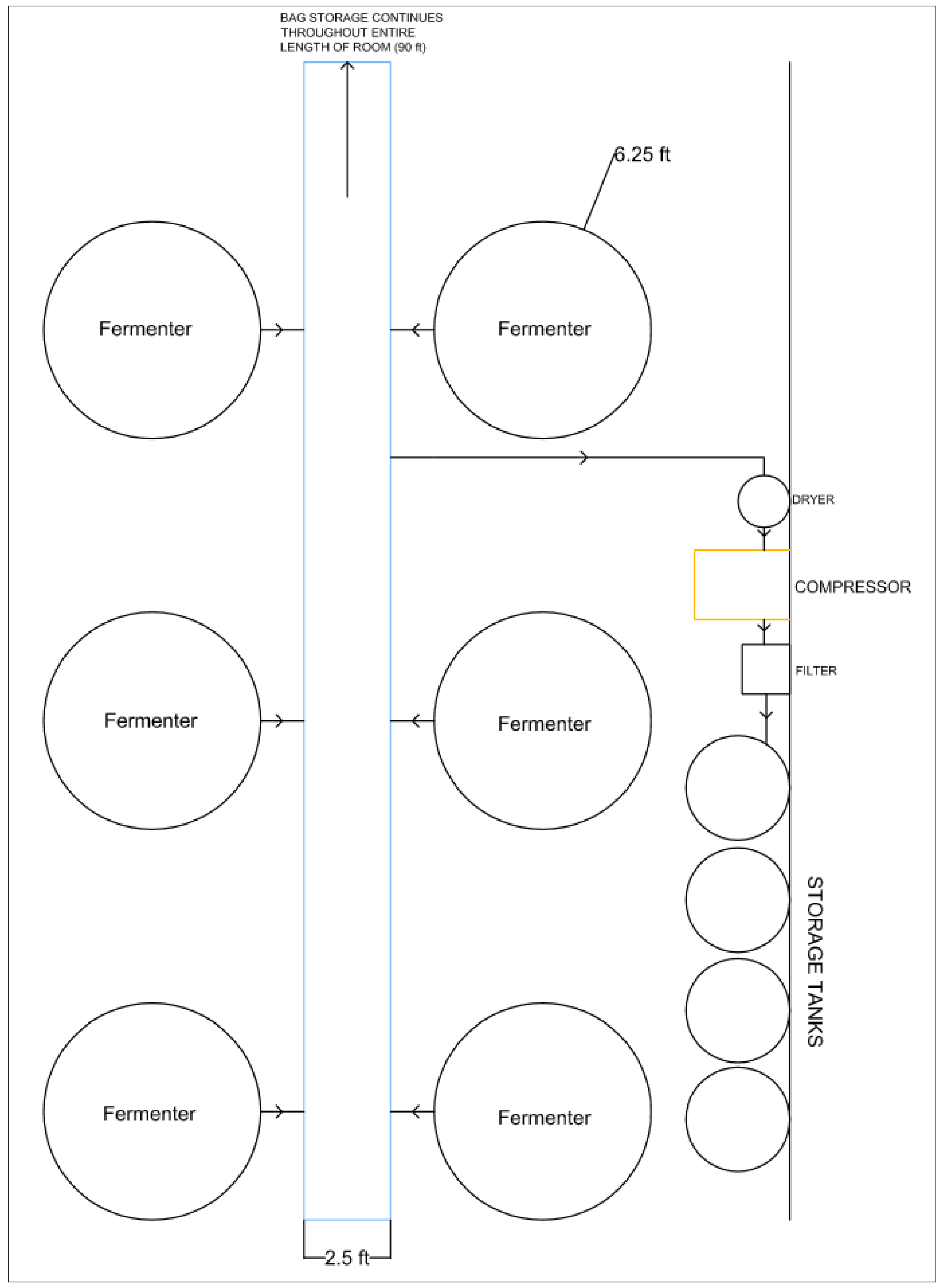

Figure 2. Designed System Top View