Green Chemical Engineering & Innovation

On-the-Go Portable reactors

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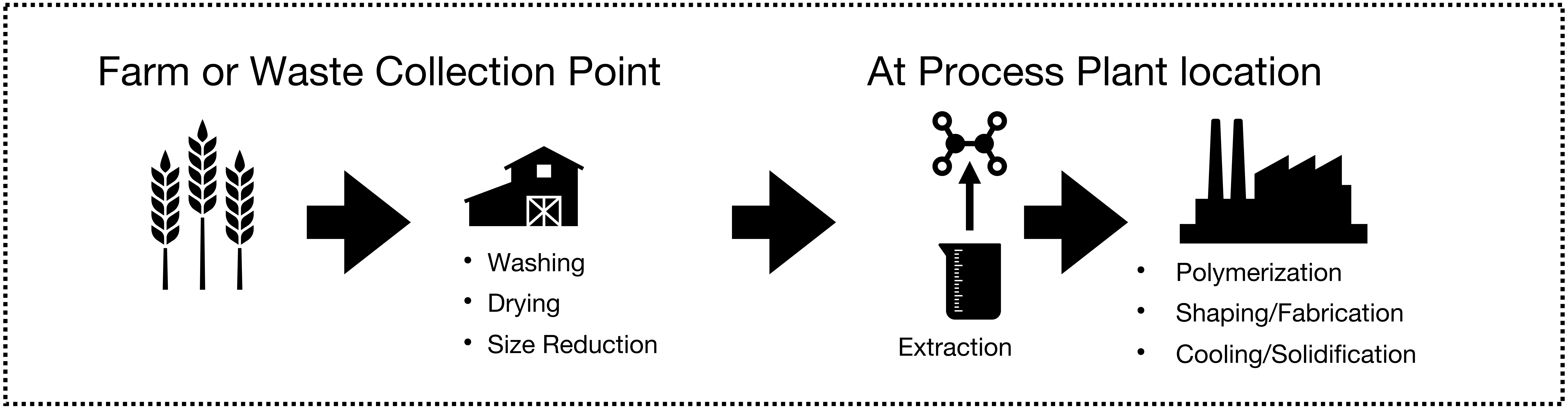
Agenda

1. Problem
2. Solution
3. Market
4. Reference
5. Appendix

Problem

Problem

Example: Sugar cane to pha production



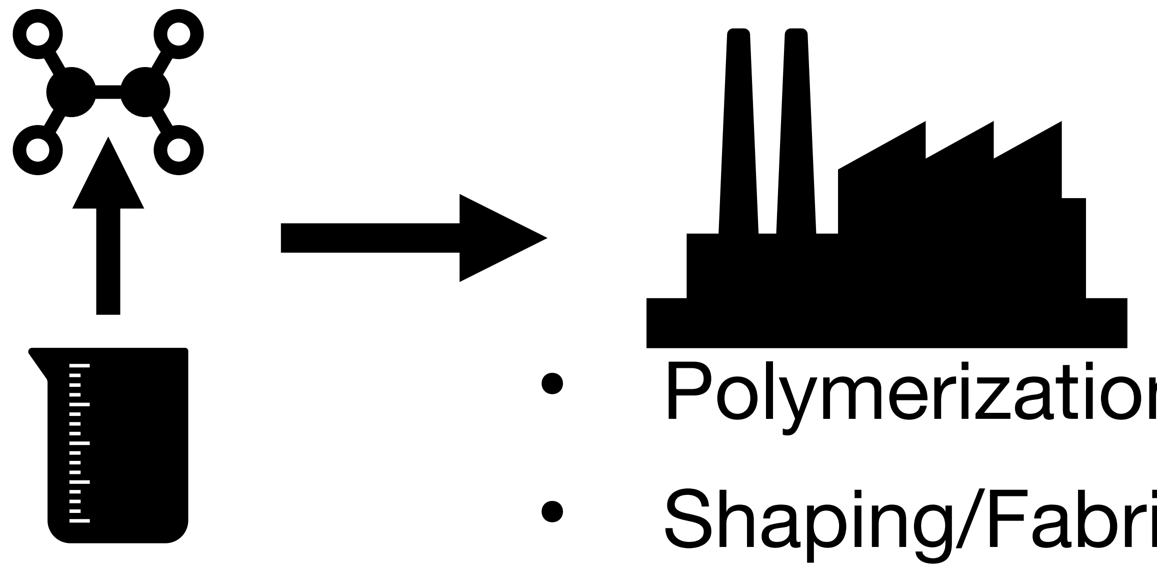
Problem

1. Feed stock contamination
2. Carbon emmision
3. Residence time varies from 1 day to 1 week

Farm or Waste Collection Point

- Washing
- Drying
- Size Reduction

At Process Plant location



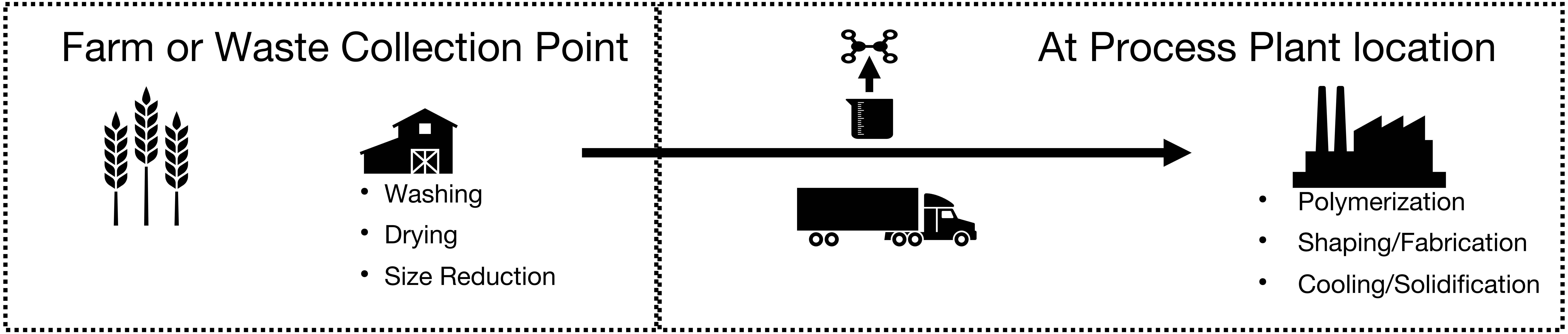
Extraction

- Polymerization
- Shaping/Fabrication
- Cooling/Solidification

Solution

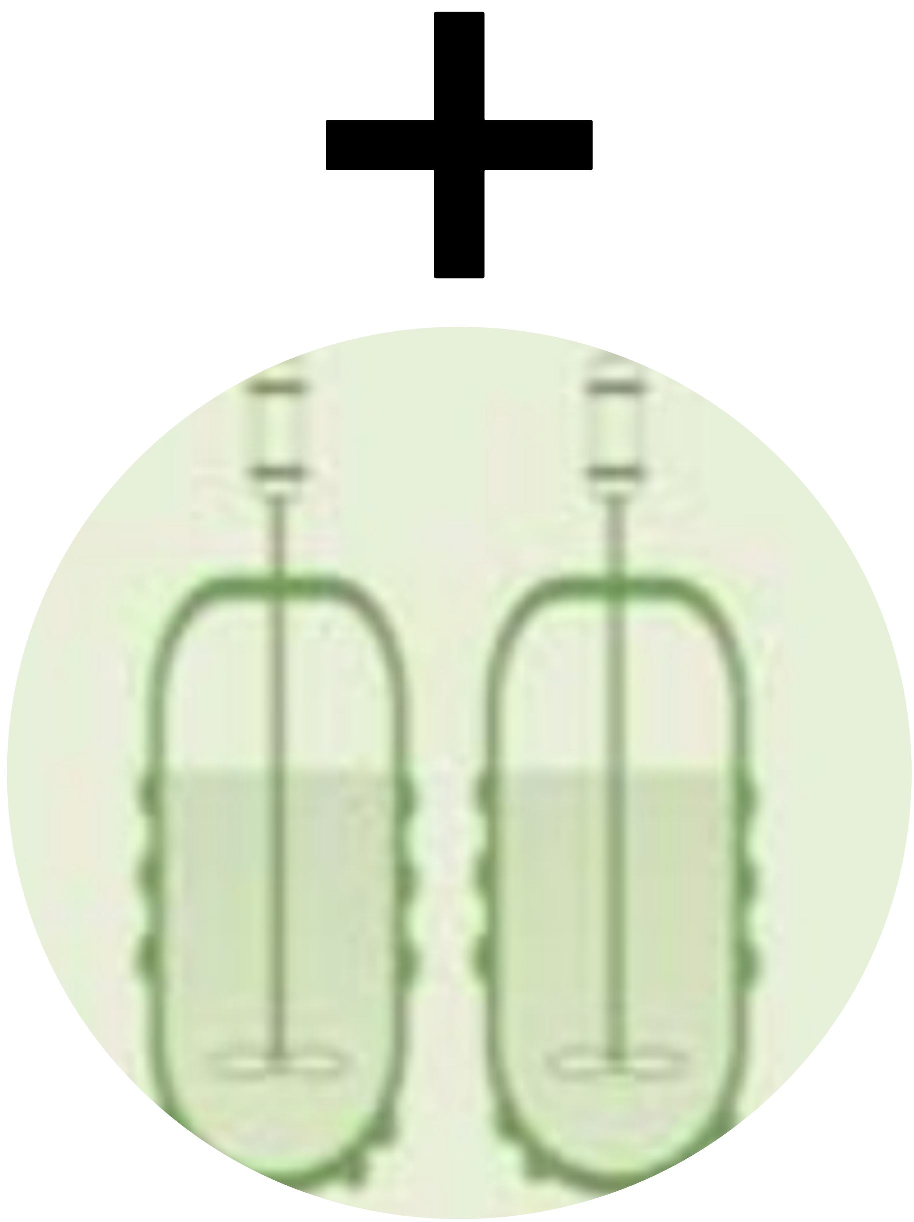
Solution

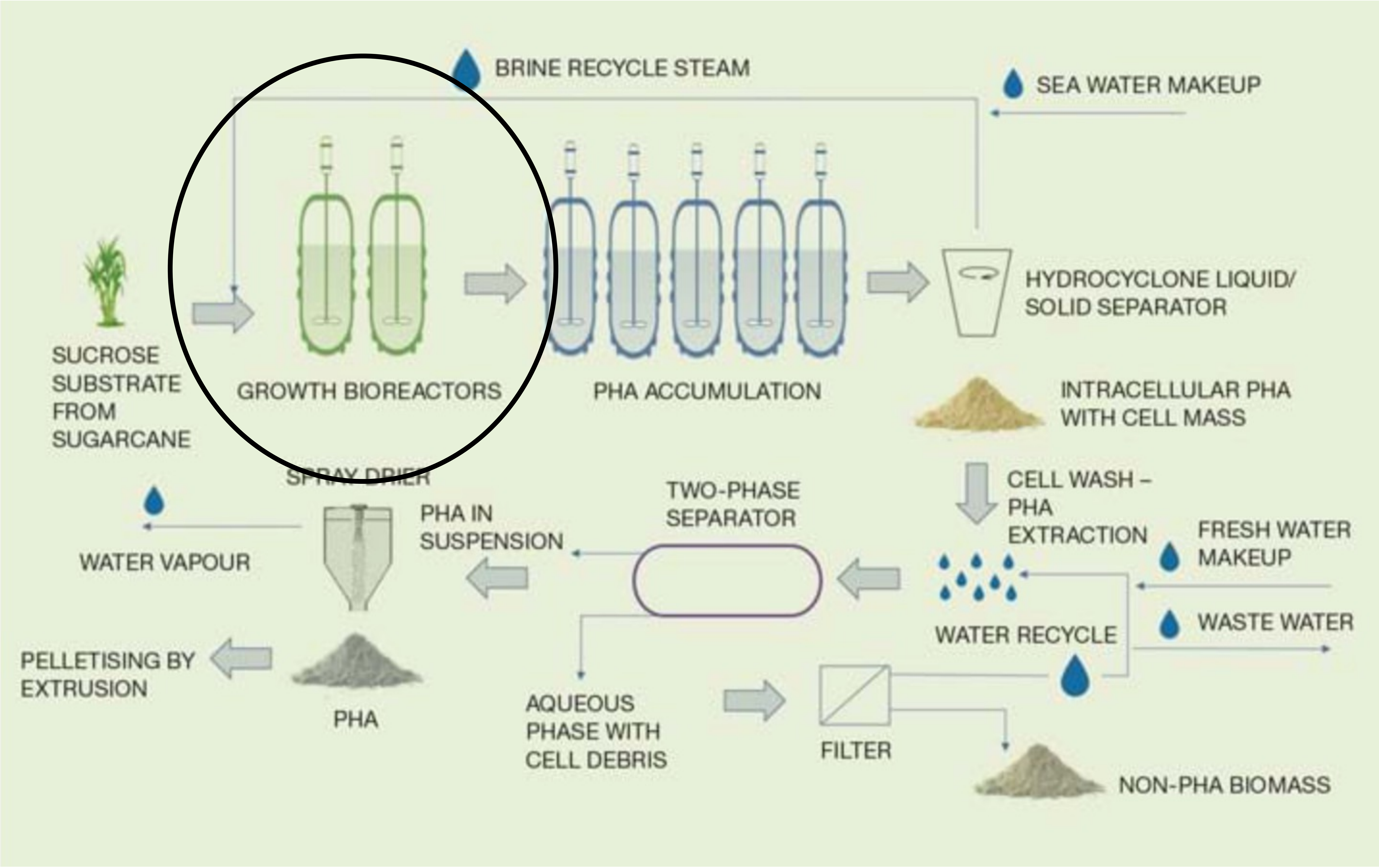
Let’s Unify the process Transportation and Feremenation



Solution

Example

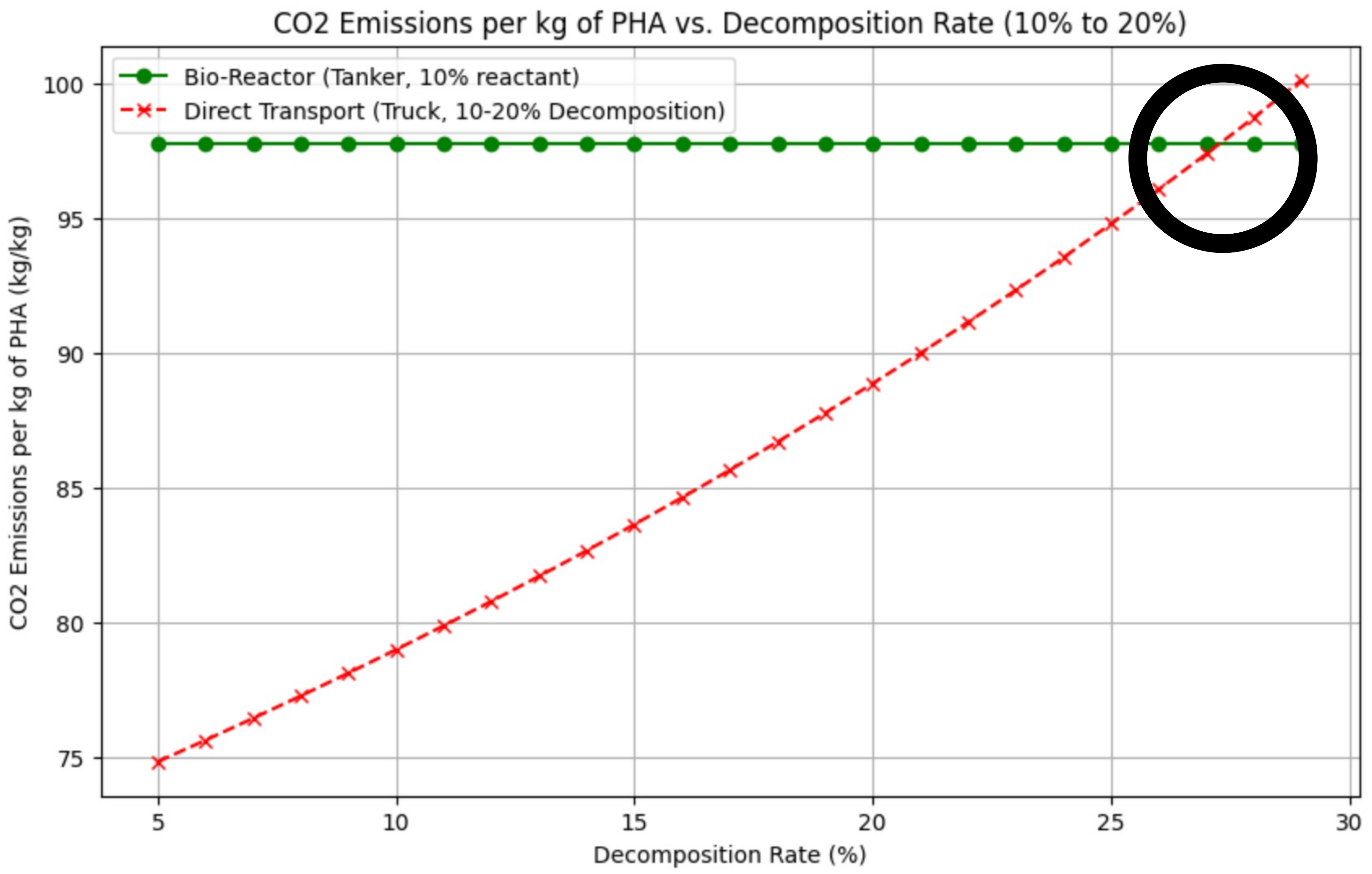


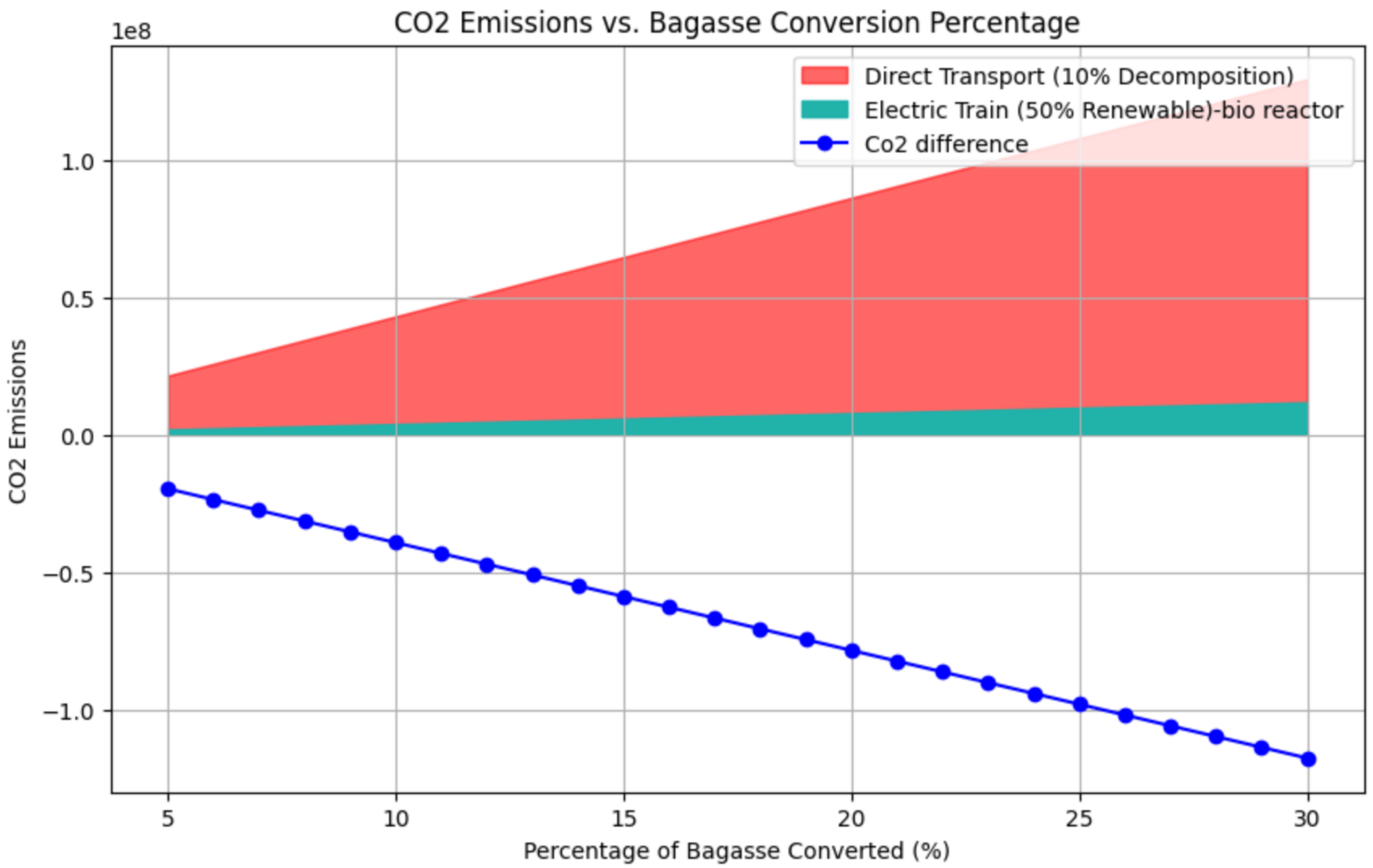


Sugar tech 17 (2015): 266-275

Solution

Carbon Emmision





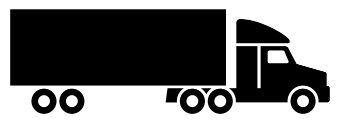
Solution

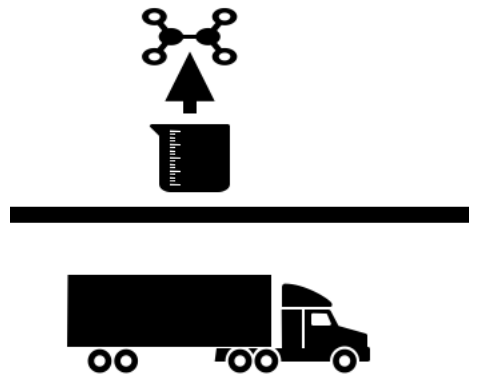
Hold On!!! how do we integrate reactor to a truck?

- The technology exists

Constraints	Where
Temperature	Oil container
Presure	Oil container
Constant air supply	Cement fermenter truck
Ph	Bio reactor

Solution





Problem	Traditionaly	Solution
Contamination	Up to 30%	Negligible
Carbon emmision	80 kg of CO2/kg PHA	7 kg of CO2/kg PHA
Process time	10 days	Ready on delivery

Lips, David. "Fuelling the future of sustainable sugar fermentation across generations." *Engineering Biology* 6.1 (2022): 3-16.

Solution

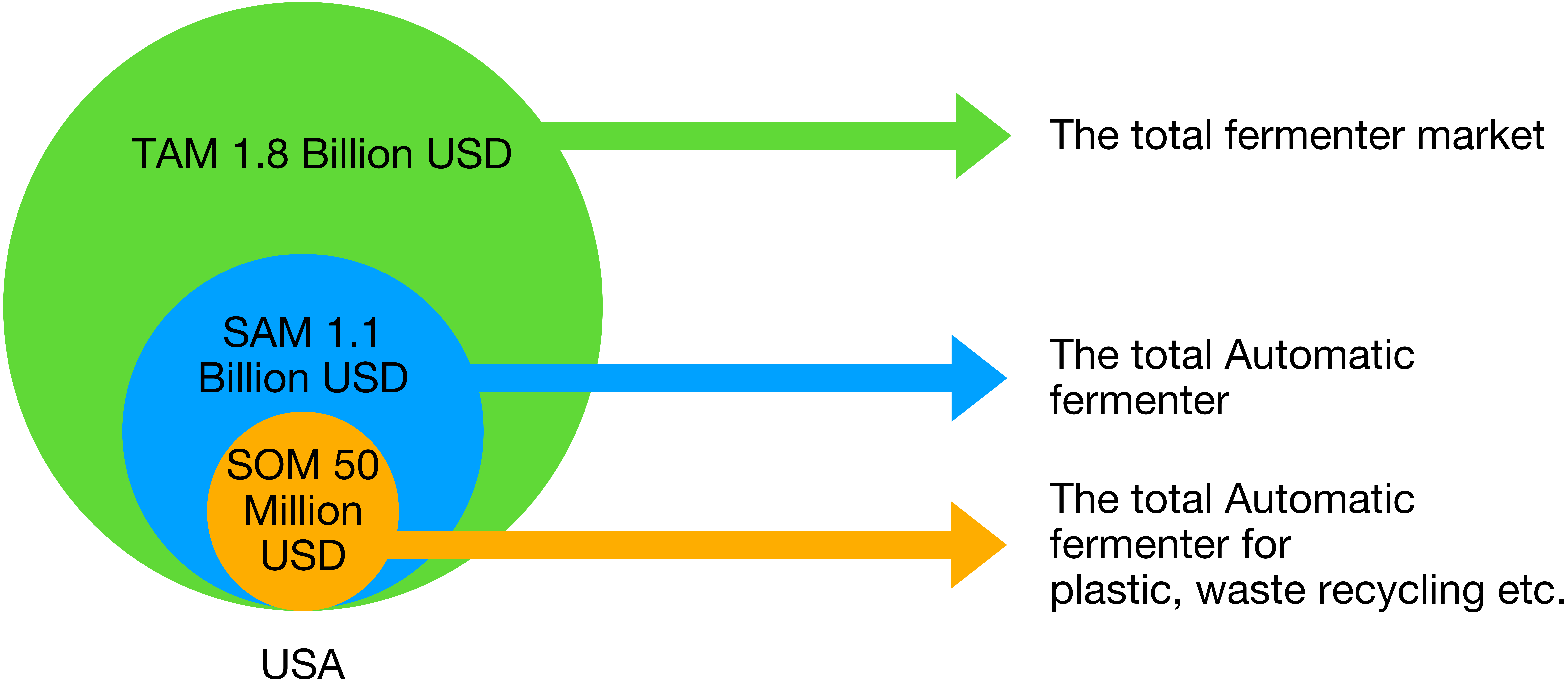
Safety

- Concerns:

1. Leaks and Spills → Double containment systems with leak detection
2. Pressure Build-up → Continuously monitor pressure levels during operation
3. Temperature Control → Insulate the fermenter
4. Biological Hazards → non-pathogenic strains of bacteria
5. Accidents and Collisions → baffle or bed to minimize movement during transport

Market

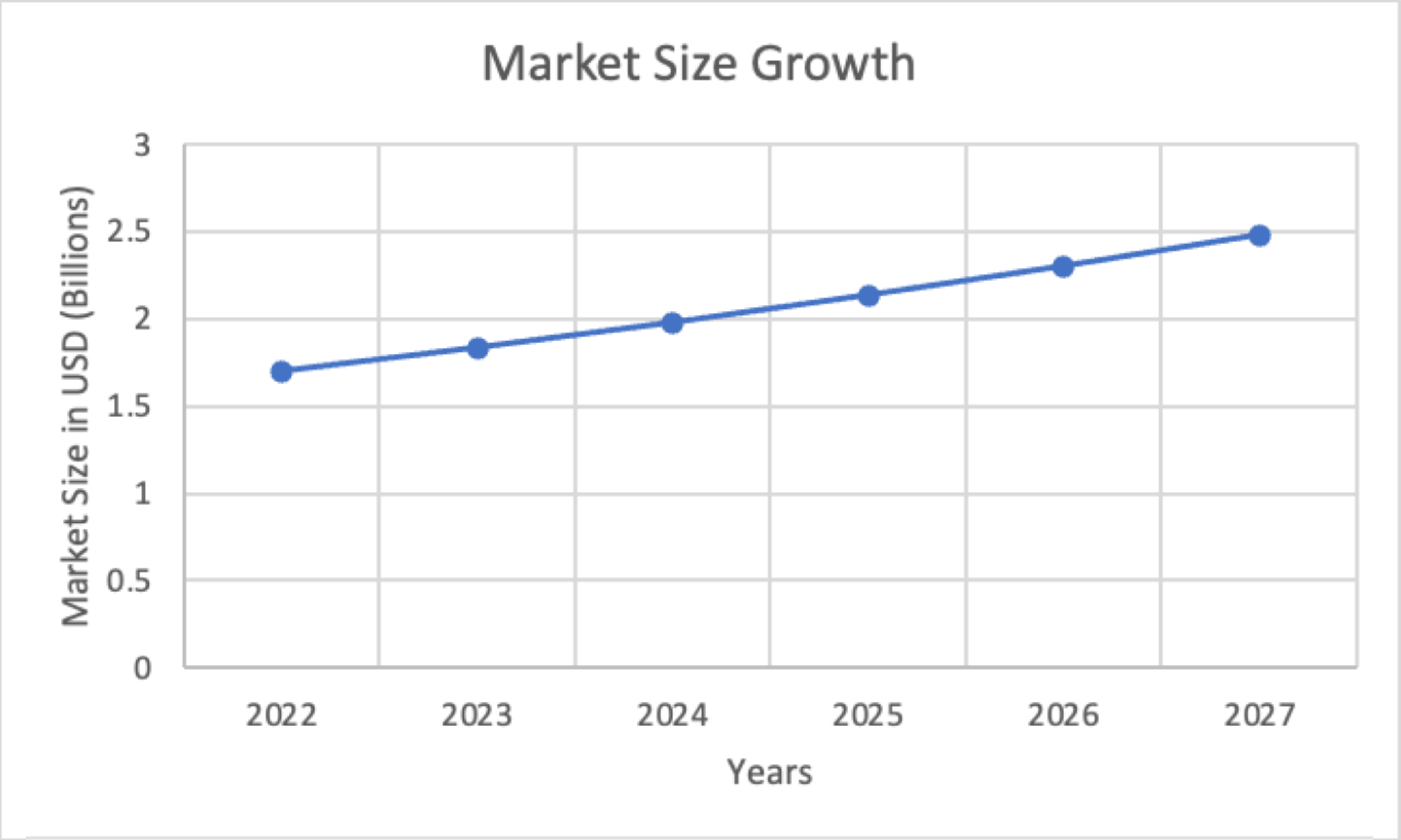
Market Analysis

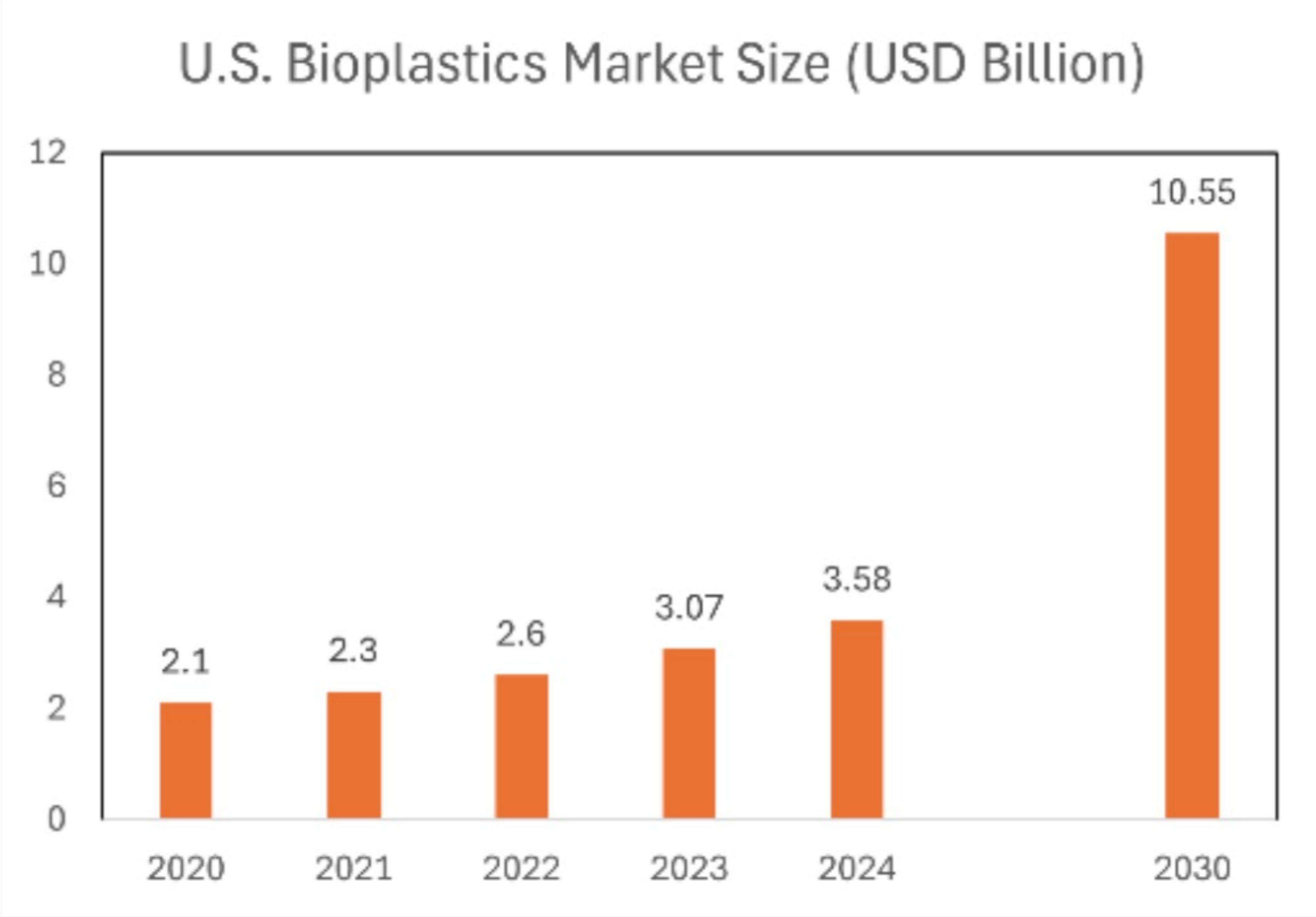


https://www.linkedin.com/pulse/fermenter-market-size-dynamics-regional-insights-segment-kashid-zjh6c/

Market Continued…

CAGR for fermenter 7.85%





- These reactors can be used in other sectors as well:

1. Biowaste Recycling in Cities.
2. Fertilizer production.
3. Biogas.

- As the need of materials like PHA and fermenters increase, Now is the time to enter the market and put reactors on the vehicles

https://www.grandviewresearch.com/industry-analysis/us-bioplastics-market-report#:~:text=U.S.%20Bioplastics%20Market%20Size%20%26%20Trends,as%20compared%20to%20traditional%20plastics.

https://www.grandviewresearch.com/industry-analysis/bioplastics-industry


On-the-Go
Portable reactors

Thank You!

Appendix

Problem

Process problems

At the Farm	Transportation	At the Plant
Baggage storage is where the baggage is stored for days before shipping which causes the nutrients content to degrade	Due to moisture and temperature, the feedstock devalues even after preprocessing	Baggage degrades in value at the storage since sometimes the fermentation is batch process

Calculation and considerations

Using Python

Daily Production Per Mill= Total Sugarcane Processed/Number of Days×Number of Mills

Total sugarcane processed: 5.3 million tonnes

Number of mills: 48

Number of days: 61

Daily Production Per Mill = 1810.1092896174862 tonnes

Bagasse production rate

bagasse_production_rate = 0.30

Calculating daily bagasse production per mill

daily_bagasse_production_per_mill = daily_production_per_mill * bagasse_production_rate

daily_bagasse_production_per_mill = 543.0327868852459

Conversion efficiency of bagasse to glucose

conversion_efficiency = 0.50

Calculating daily glucose production per mill

daily_glucose_production_per_mill = daily_bagasse_production_per_mill * conversion_efficiency

daily_glucose_production_per_mill = 271.5163934426229

Decomposition rates from 5% to 15%

1. Zhou, Tanlong, et al. "Polyhydroxyalkanoates production from lactic acid fermentation broth of agricultural waste without extra purification: The effect of concentrations." *Environmental Technology & Innovation* 32 (2023): 103311.
2. https://www.energy.gov/sites/default/files/2016/01/f28/QTR2015-7B-Biomass-Feedstocks-and-Logistics.pdf
3. Patil, P. T., and K. C. Ramotra. "Investigating the Orientation of Sugar Industries and Practice of Industrial Relocation for Sugar Industries in Kolhapur District." and related articles

Sustainable Goals alignment

- Our company aligns with goal 12 – Responsible Consumption And Production

Reference:

1. Solís-Fuentes, J. A., E. Raga-Carbajal, and M. C. Durán-de-Bazúa. "Direct sucrose hydrolysis in sugarcane juice with immobilized invertase: multi-response optimization using desirability function on conversion and reactor volumetric productivity." *Sugar tech* 17 (2015): 266-275.
2. Montipó, Sheila, et al. "Bioprocessing of rice husk into monosaccharides and the fermentative production of bioethanol and lactate." *Cellulose* 26 (2019): 7309-7322.
3. Zhou, Tanlong, et al. "Polyhydroxyalkanoates production from lactic acid fermentation broth of agricultural waste without extra purification: The effect of concentrations." *Environmental Technology & Innovation* 32 (2023): 103311.
4. https://www.energy.gov/sites/default/files/2016/01/f28/QTR2015-7B-Biomass-Feedstocks-and-Logistics.pdf
5. Wang, Jiaxiu, et al. "Biobased materials for food packaging." Journal of Bioresources and Bioproducts 7.1 (2022): 1-13.
6. https://www.linkedin.com/pulse/fermenter-market-size-dynamics-regional-insights-segment-kashid-zjh6c/
7. Patil, P. T., and K. C. Ramotra. "Investigating the Orientation of Sugar Industries and Practice of Industrial Relocation for Sugar Industries in Kolhapur District." and related articl

Slide Notes

Slide 4

- **At the Sugarcane Farm:**

1. **Harvesting:** Sugarcane stalks are harvested from the fields.
2. **Preparation:** The stalks might be chopped or crushed to facilitate further processing.

- **At Sugarcane Processing Facility:**

3. **Extraction:** The juice containing sucrose (sugar) is extracted from the crushed sugarcane. This can be done through mechanical pressing or diffusion methods.
4. **Clarification:** The juice is clarified to remove impurities like proteins, waxes, and bagasse (fibrous material remaining after extraction).
5. **Concentration:** The clarified juice is concentrated to increase the sugar content. This can be achieved through evaporation techniques.

- **PHA Biosynthesis using Fermenter:**

6. **Feedstock Preparation:** The concentrated sugarcane juice (or sometimes molasses, a byproduct of sugar production) is used as a carbon source for the PHA-producing bacteria. It might undergo further dilution or sterilization depending on the process.
7. **Selection and Inoculation:** A specific strain of bacteria known for PHA production, like *Cupriavidus necator*, is chosen and cultured in a seed fermenter. This concentrated culture is then used to inoculate the main production fermenter.
8. **Fermentation:** The sterilized sugarcane juice (feedstock) is introduced into the main fermenter along with essential nutrients like nitrogen, phosphorus, and minerals. The fermenter provides controlled conditions like temperature, pH, and agitation to optimize bacterial growth and PHA production.
9. **Cell Harvesting:** Once enough PHA is accumulated inside the bacteria, the fermentation process is stopped. The bacterial cells containing PHA are then separated from the broth through techniques like centrifugation.
10. **PHA Recovery:** The cells are disrupted to release the PHA biopolymer. This might involve various methods depending on the specific process, potentially using enzymes or solvents.
11. **Purification:** The recovered PHA is purified to remove any remaining cellular components or impurities.
12. **Drying and Finishing:** The purified PHA is dried to remove any residual solvents or water. Depending on the desired final product form, the PHA might undergo further processing steps like granulation or shaping.

Slide Notes

Slide 5 - This is an inefficiency in the process. There are extra carbon emissions, devaluing of the feedstock during transportation from the feed source to the process plant.

Slide 7 - Our product is to put reactors on the back of vehicles. Where feed stock can be processed behind the vehicle, be as it train or truck it helps in reducing the feed stock degradation.

Slide 8 - Just an example diagram for information, which part of the upstream process of PHA production we are integrating.

Slide 9 - **transportation is a carbon dioxide-expensive process. we emit a lot of co2 with large reactors on the back of trucks or tankers. the first graph on the right shows the Co2 per kg of PHA Vs decomposition rate. The crossover at the top of the curve at 23% feedstock decomposition. 23% degradation happens when the distance is large, which gives us an opportunity to target plants located far away from the source. if the distance is longer than that we can put it on trains which has much lower emissions and better performance.**

Bio-Reactor Scenario: Here, bagasse is processed into glucose, which is then converted into PHA. The transportation of bagasse and PHA is done using tankers. CO2 emissions are calculated based on the round-trip distance and tanker emission factor.

Direct Transport Scenario: In this scenario, bagasse is partially decomposed, reducing its quantity. Glucose is produced from the remaining bagasse and then converted into PHA. Transportation of bagasse and PHA is carried out using trucks. CO2 emissions are calculated considering the round-trip distance and the emission factor for trucks.

The decomposition rates considered range from 10% to 20%. For each decomposition rate, the script calculates the total CO2 emissions per kg of PHA produced for both scenarios. Finally, it plots the CO2 emissions per kg of PHA against the decomposition rate, allowing for comparison between the two scenarios.

Slide 14 - We are going to target a market of 50 million USD. This includes the locations that are far enough that 23% degradation of feed stock occurs.