

# Susterra® Propanediol Heat Transfer Fluids



**Performance is in our nature.**

March 11, 2016



# Who is DuPont Tate & Lyle?

DTL is a joint venture formed in 2004 between DuPont and Tate & Lyle to produce 1,3 propanediol (PDO) from corn starch, a sustainable & renewable resource



DuPont is a world leader in science and innovation across a range of disciplines, including agriculture and industrial biotechnology, chemistry, biology, materials science and manufacturing. CY2015 revenues were \$35 billion.



Tate and Lyle is a global provider of renewable ingredients, solutions and services to the food, beverage and industrial customers. Revenues were \$4.3 billion for Fiscal Year ending March 31, 2015.



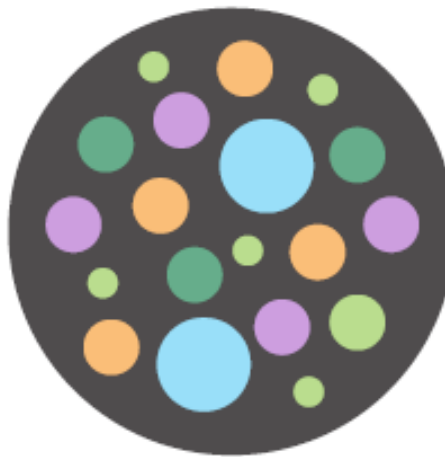
# Process Technology

Renewably sourced feedstocks are harvested, fermented, and refined to manufacture Susterra® propanediol.



## Harvest

Renewably sourced feedstocks are harvested, dried and then wet-milled to create a range of carbohydrate rich feedstocks such as glucose.



## Fermentation

Glucose is converted into 1,3 propanediol using a patented microorganism under exact temperatures and conditions.



## Refining

The 1,3 propanediol is refined to a final purity of 99.7% by deactivating and removing the microorganism, water, and other byproducts.

# Production

Biotechnology enables our global headquarters and production in Loudon, Tennessee to produce a stable supply of renewably sourced 1,3 propanediol



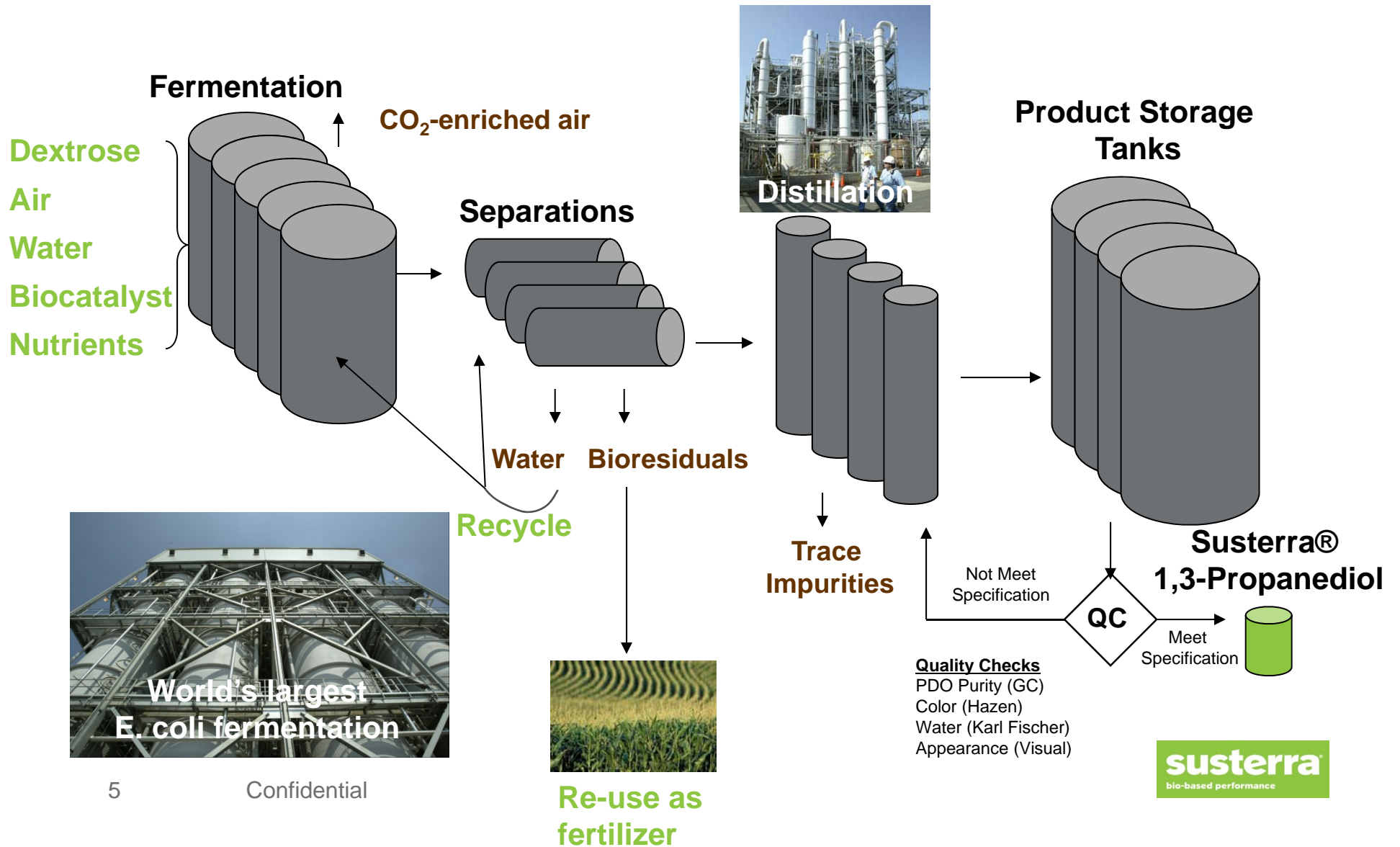
## Awards

- 2003 EPA Presidential Green Chemistry Award
- 2007 ACS Heroes of Chemistry Award
- 2009 ACS-BIOT Industrial Biotechnology Award
- 2010 State of Tennessee Governor's Award for Trade Excellence

## Production

- Started November 2006
- Capacity expanded 35% in 2010
- Current Capacity = 140 million lb.

# Susterra® Propanediol Process Flow

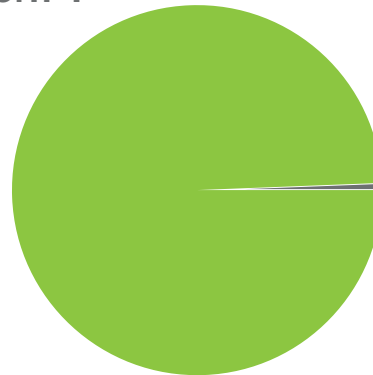


# Field Corn vs. Sweet Corn

Susterra® propanediol is derived from U.S. Field Corn

## Yellow Dent or “Field Corn”:

90.6 MM planted acres  
14.2 B bushels produced  
Crop Value: \$51.9 B



## Sweet Corn:

0.555 MM planted acres  
137 MM bushels produced  
Crop Value: \$1.02 B

### Yellow Dent Facts:

- Grown on over 99% of U.S. corn field acres
- Produced for ethanol, livestock feed, cereals, and other manufactured goods
- Considered a grain
- Harvested when kernels are dry and mature

### Sweet Corn Facts:

- Grown on less than 1% of U.S. corn field acres
- Consumed by humans
- Considered a vegetable
- Harvested when kernels are soft and immature

# Field Corn

Susterra® propanediol utilizes the starch in the field corn while the other components are harvested for different applications including animal feed for livestock.

Yellow Dent Corn Components:

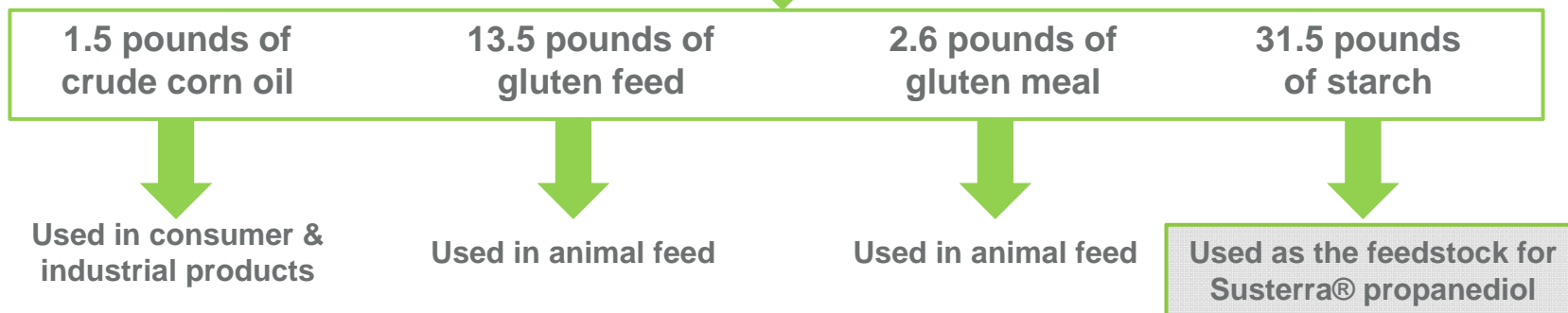


- 62% Starch
- 19.2% Protein & Fiber
- 15% Moisture
- 3.8% Corn Oil



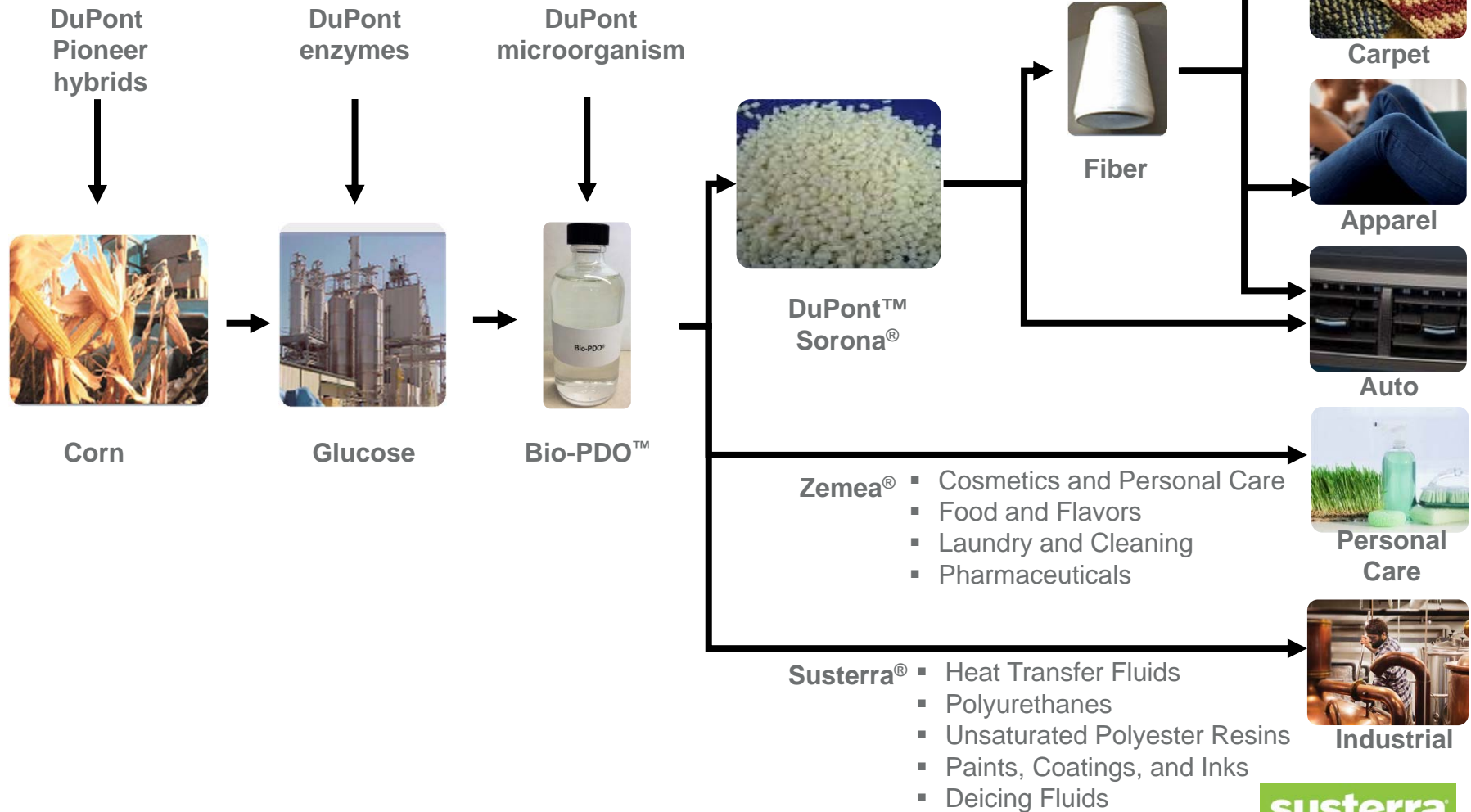
One bushel of wet-milled field corn

*Produces*



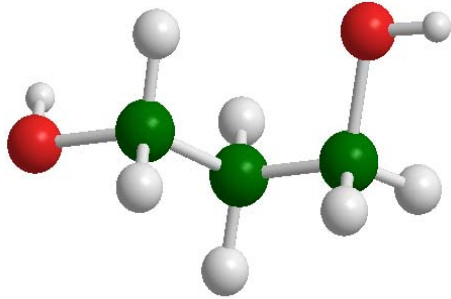
# Susterra® Propanediol

From the Field to Market Applications





# Susterra® Propanediol



## What is it?

- A pure, petroleum-free derived glycol
- 100% sustainably and renewably sourced
- Used in a range of applications



## How is it made?

- Made by a fermentation process derived from glucose
- Made in the USA
- USDA 100% Certified Bio-Based Product
- GRAS, Halal, Kosher
- Ingredient for use in Heat Transfer Fluids with Incidental Food Contact (HTX-1)

# Susterra® Propanediol

Performance advantages in heat transfer fluids

- Less thermal degradation compared to EG and PG
- Higher boiling point vs EG and PG based fluids

# Susterra® Propanediol

## Glycol comparison – high temperature reflux

**Objective:** Evaluate the performance of glycol heat transfer fluid systems simulating a stagnant high thermal event for a semi-closed loop heat transfer system.

Reflux time: 16 hours  
Reflux temperature: 192 ± 10 °C  
Inhibitor package: 2.2% Penray 2792  
Dilution: 50% deionized water  
Glycols: Susterra® propanediol, propylene glycol, and ethylene glycol

**Glycol cracking occurs as heat transfer fluid sees temperature fluctuations, producing corrosive organic compounds and darkened fluid.**

### Visual appearance of fluids after reflux



Propylene Glycol

1,3 Propanediol

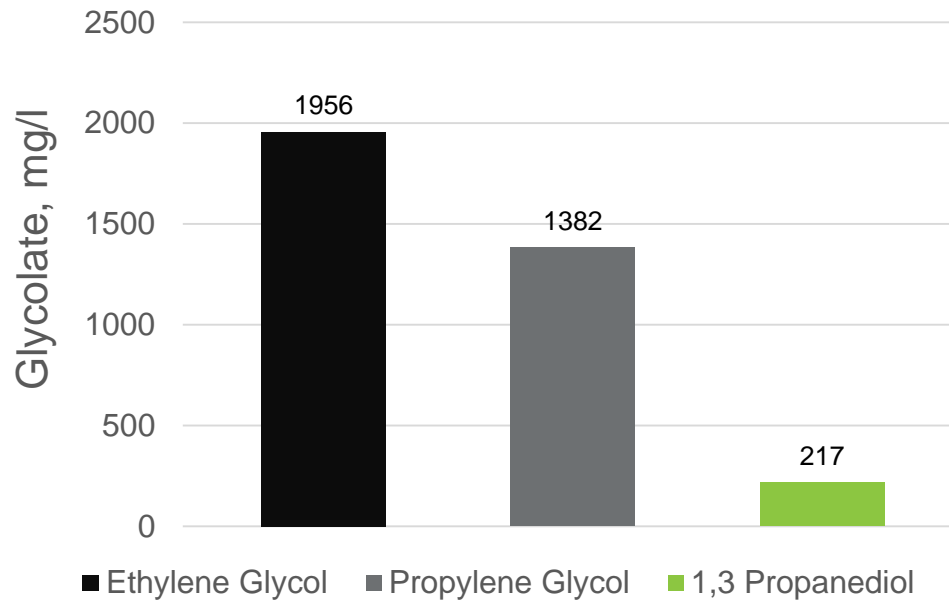
Ethylene Glycol

# Susterra® Propanediol

Glycol comparison – high temperature reflux

**Objective:** Evaluate the performance of glycol heat transfer fluid systems comparing glycolate formation in inhibited glycols after reaching its boiling point.

### Glycolate Formation with Inhibited Glycols

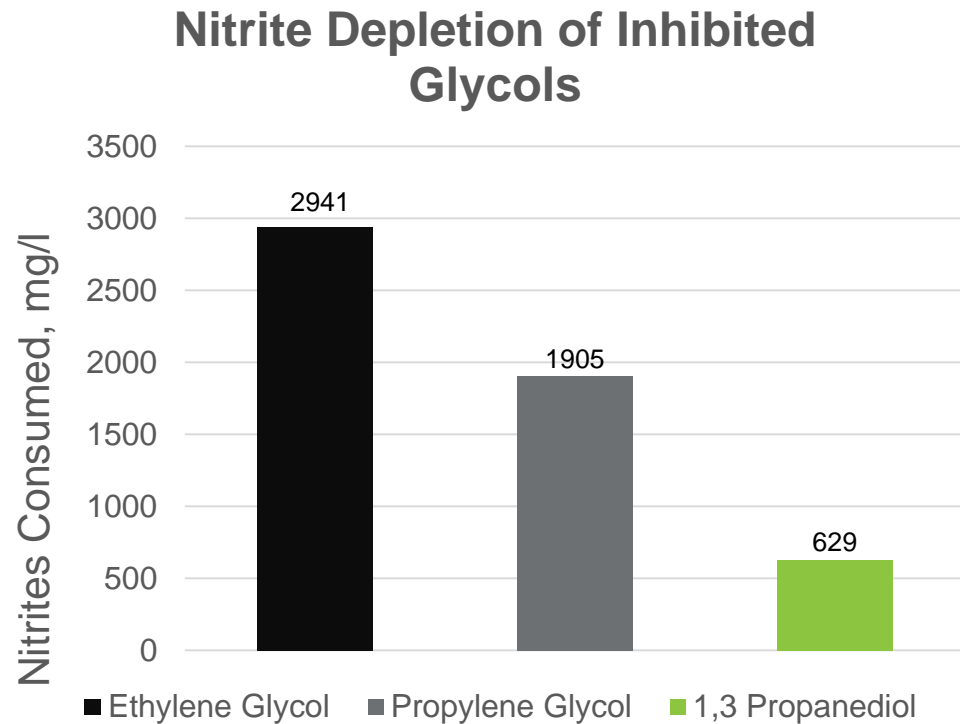


The Susterra® propanediol based fluid produced fewer Glycolates, a thermal decomposition product of glycol, than the inhibited PG and EG fluids.

# Susterra® Propanediol

Glycol comparison – high temperature reflux

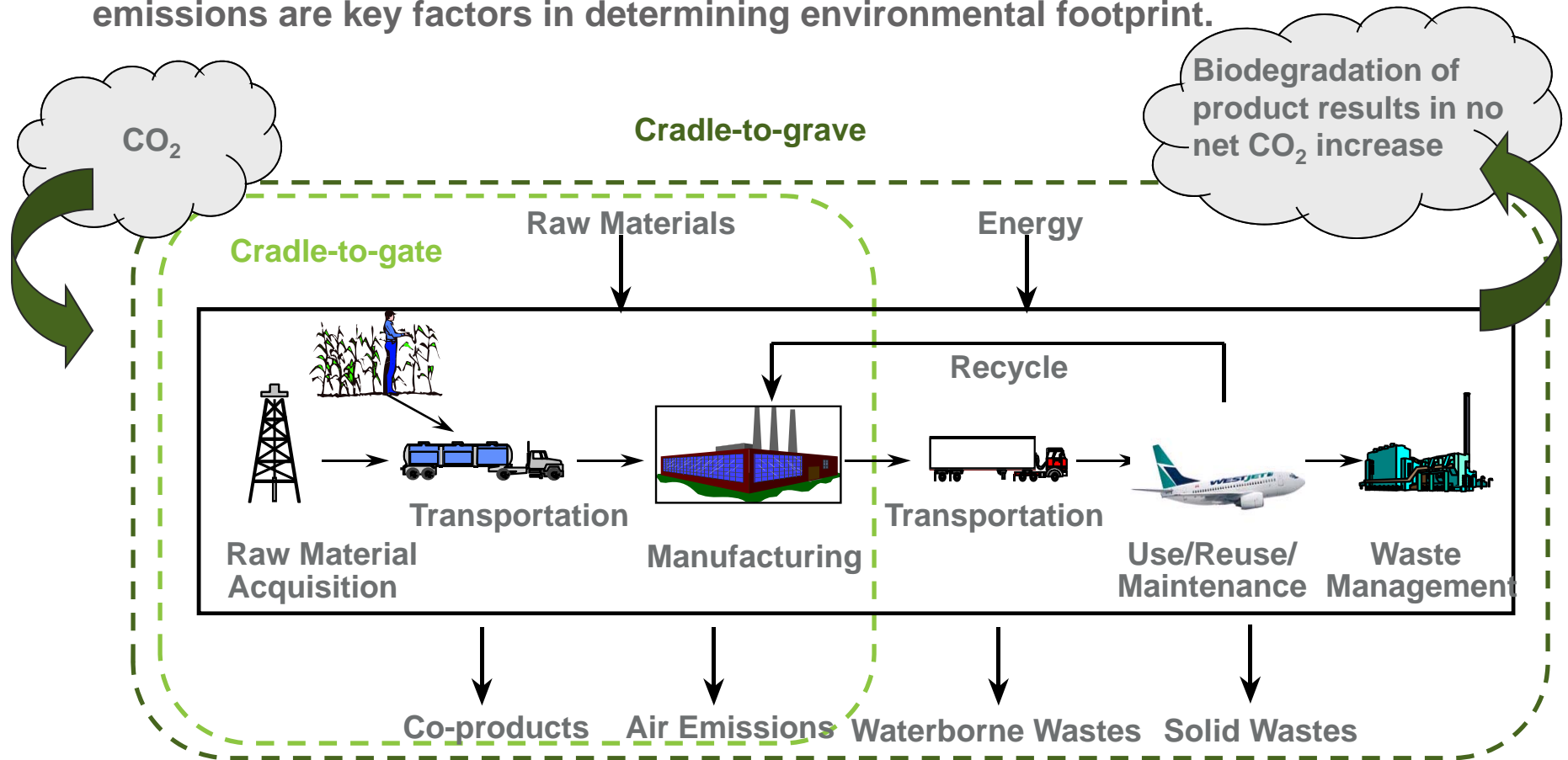
**Objective:** Evaluate the performance of glycol heat transfer fluid systems comparing nitrite depletion of inhibited glycols after reaching its boiling point.



The Susterra® propanediol based fluid retained more nitrites than the inhibited PG and EG fluids. Conversion of nitrite ( $\text{NO}_2$ ), found in the inhibitor package, to nitrate ( $\text{NO}_3$ ) indicates that significant higher level of oxidation products are present in the EG and PG fluids after boiling.

# Life Cycle Analysis (LCA)

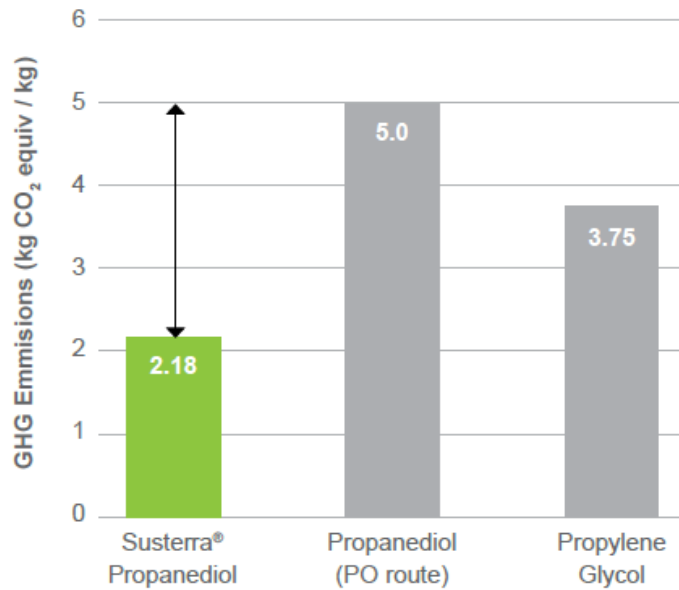
LCA is the only standardized method to evaluate the environmental footprint of a whole supply chain. Energy consumption and Green House Gas (CO<sub>2</sub>) emissions are key factors in determining environmental footprint.



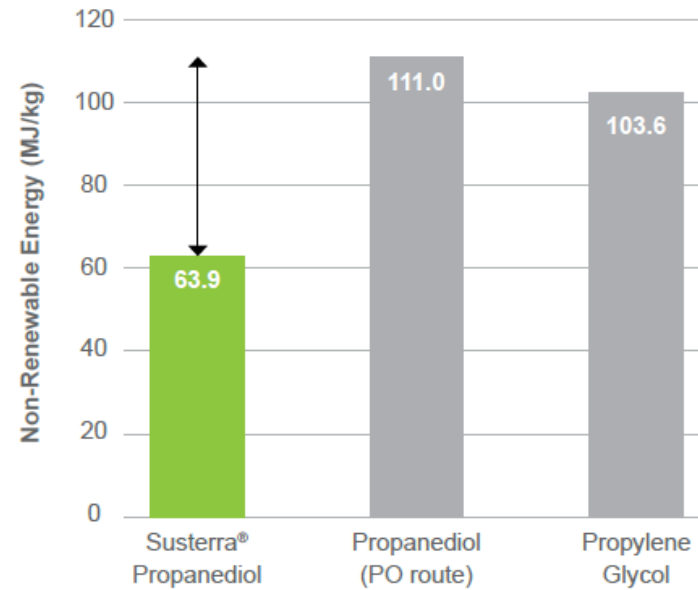
# Life Cycle Analysis

## Susterra® propanediol

From “cradle to gate” (extraction and production prior to delivery to the consumer), Susterra® propanediol produces 56% less greenhouse gas emissions and consumes 42% less nonrenewable energy than petroleum-based 1,3-propanediol. Compared with propylene glycol, Susterra® propanediol produces 42% less greenhouse gas emissions and uses 38% less nonrenewable energy from cradle to gate.



**Greenhouse Gas Emissions**  
56% less than Propanediol  
42% less than Propylene Glycol



**Non-Renewable Energy Use**  
42% less than Propanediol  
38% less than Propylene Glycol



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