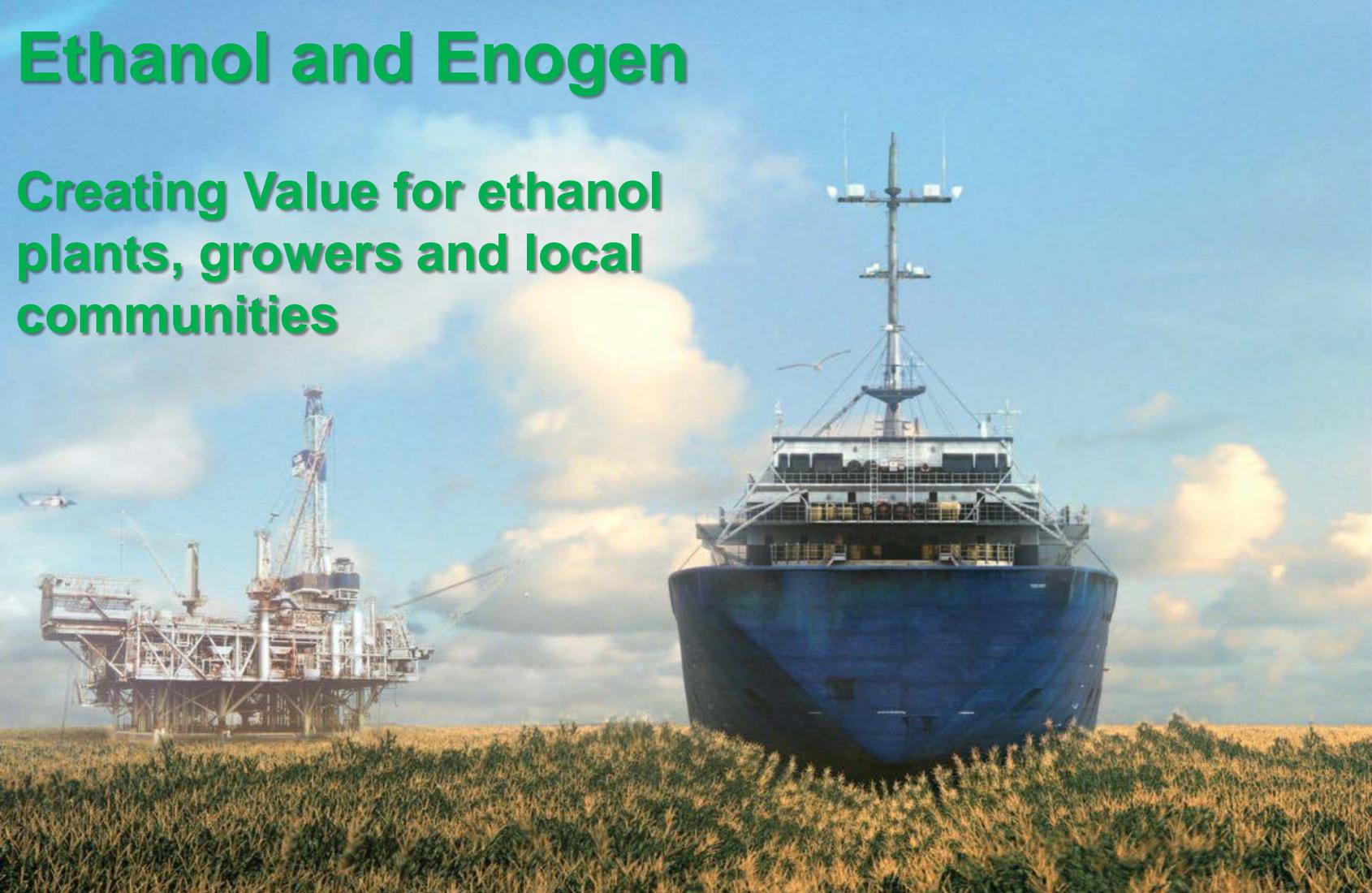


# Ethanol and Enogen

Creating Value for ethanol plants, growers and local communities



 **Enogen**<sup>®</sup>

syngenta

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# Topics for Today

- Syngenta's commitment to ethanol
- Enogen
  - Technical profile
  - Status of the business
- Cellerate
  - Overview of the technology
  - Performance Results
- Carbon Intensity
  - Enogen benefits
  - Ethanol Grower Advantage

# Syngenta's Ethanol Strategy: 4 Key Elements focused on the Supporting the Grower, Industry, and Community



# Syngenta's Commitment to the Ethanol Industry



- \$200+ million to bring technology to market.
- Dedicated Enogen field team to connect growers to ethanol plants and ethanol plants to technology.
- Enables significant efficiencies and community impact.



- First commercially viable cellulosic ethanol process
- Converts fiber in kernel to cellulosic ethanol
- Can raise ethanol yields up to 6% and produce higher protein DDGs.



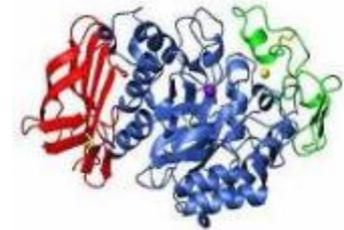
- Prime the Pump: \$1 / acre donation to ethanol industry from Enogen acres from 2013 – 2016 ≈ \$800K
- For 2016, Syngenta will have converted 80% of their U.S. fleet to Flex-Fuel vehicles.

# Enogen a new technology for ethanol and growers

Enogen corn enzyme technology features the first biotech corn output trait for ethanol production.

This breakthrough technology is delivered through a high-value grain system that has the potential to greatly benefit consumers, growers and the ethanol industry.

**Enogen technology enables ethanol process flexibility that creates increased profit potential for ethanol producers.**

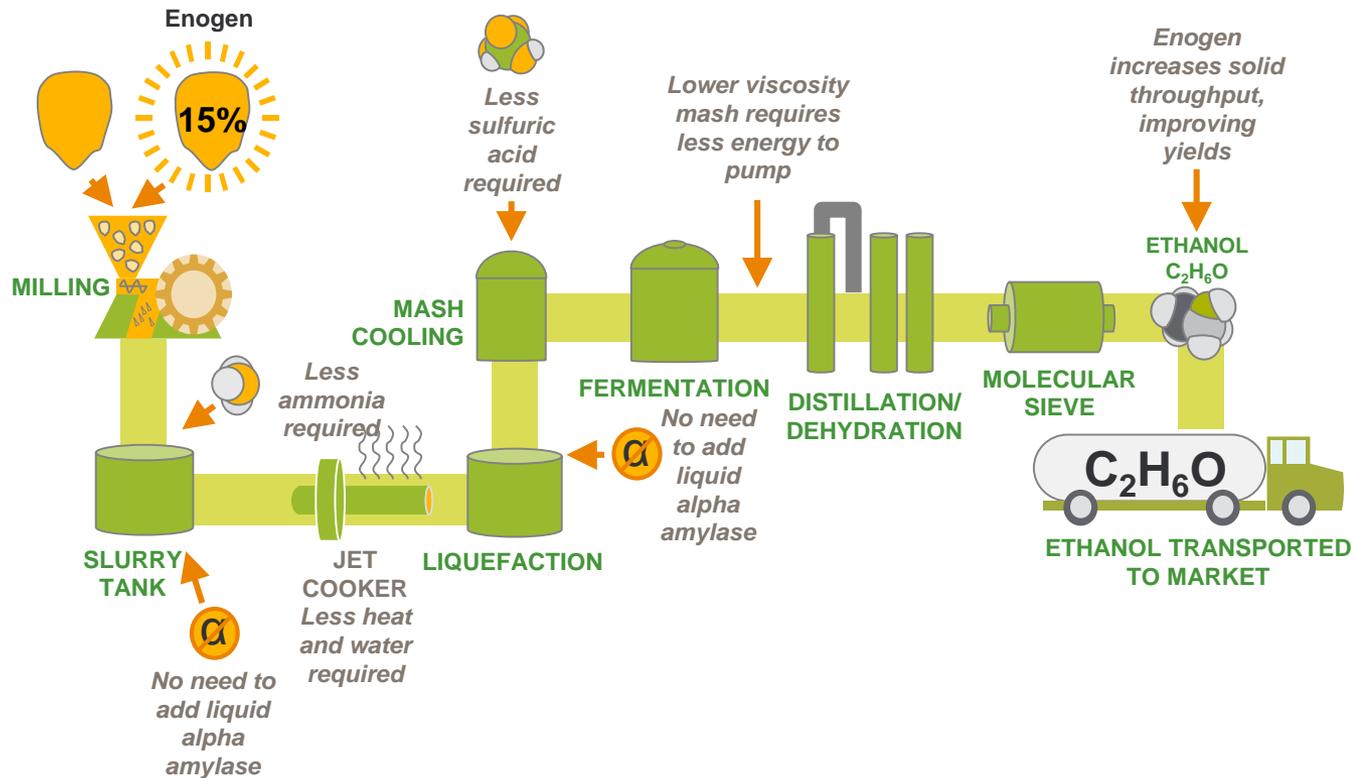


alpha-amylase



# How does Enogen create value?

Enogen replaces liquid alpha amylase in ethanol production and delivers incremental value



A high-level illustration of how Enogen works in ethanol plants

# What is Enogen? – Value of the Technology

## Ethanol Plant

Helps increase ethanol production  
Helps to reduce inputs and a lower carbon footprint



## Grower

Enogen growers receive an additional 40¢ per bushel (on average) and contribute to an industry that is responsible for a more stable corn market and domestic energy source



## Community

≥ 10% reduction in carbon footprint and GDP impact<sup>1</sup>  
(≈\$2.2M in premiums<sup>2</sup>)

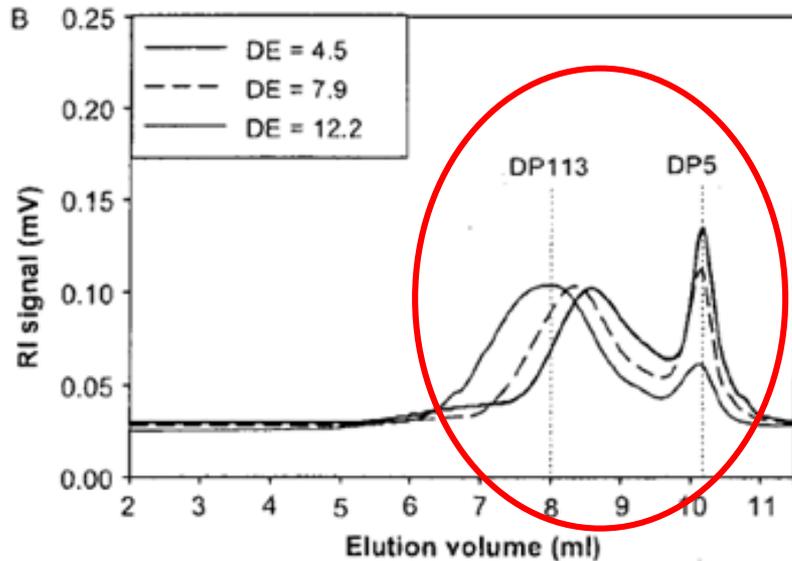


<sup>1</sup>Calculations based on Enogen trial and commercial results at Midwest Ethanol Plants

<sup>2</sup>Premiums generated if a 100 Mmgy ethanol plant converted to Enogen

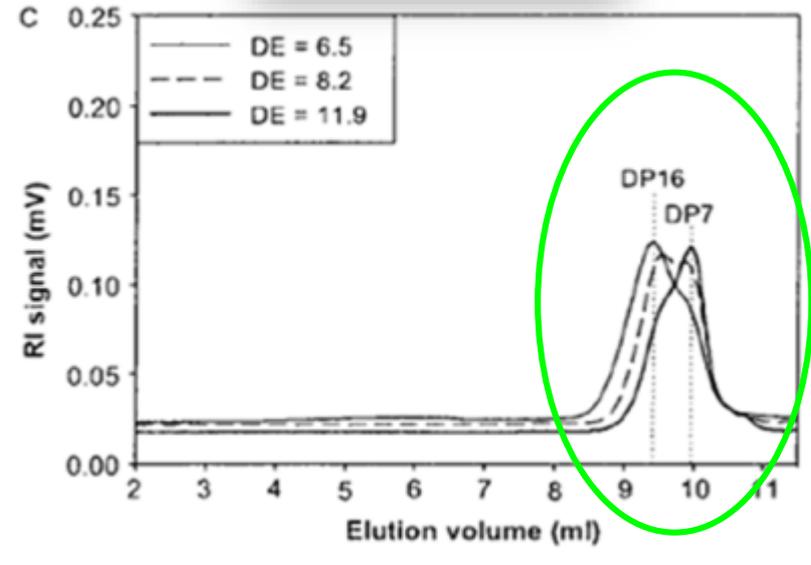
# How does Enogen compare to conventional alpha-amylase\*?

## Conventional AA



## Conventional AA

- Multiple Attack Hydrolysis
- Broad spectrum size distribution
- High concentration of large chains
- High viscosity mash



## Enogen:

- Random Attack Hydrolysis
- Narrowly defined size distribution
- No large chains, refined to small chains
- Drastic reduction in mash viscosity

**The difference in enzyme mechanics cannot be overcome by increased dosage.**

\*Atichokudomchai et al., 2006. Carbohydrate Polymers 64: 582-288.

# Enogen demonstrates immediate energy savings\*



\*2014 Enogen Trial with Vogelbusch-75mgpy Plant Type.

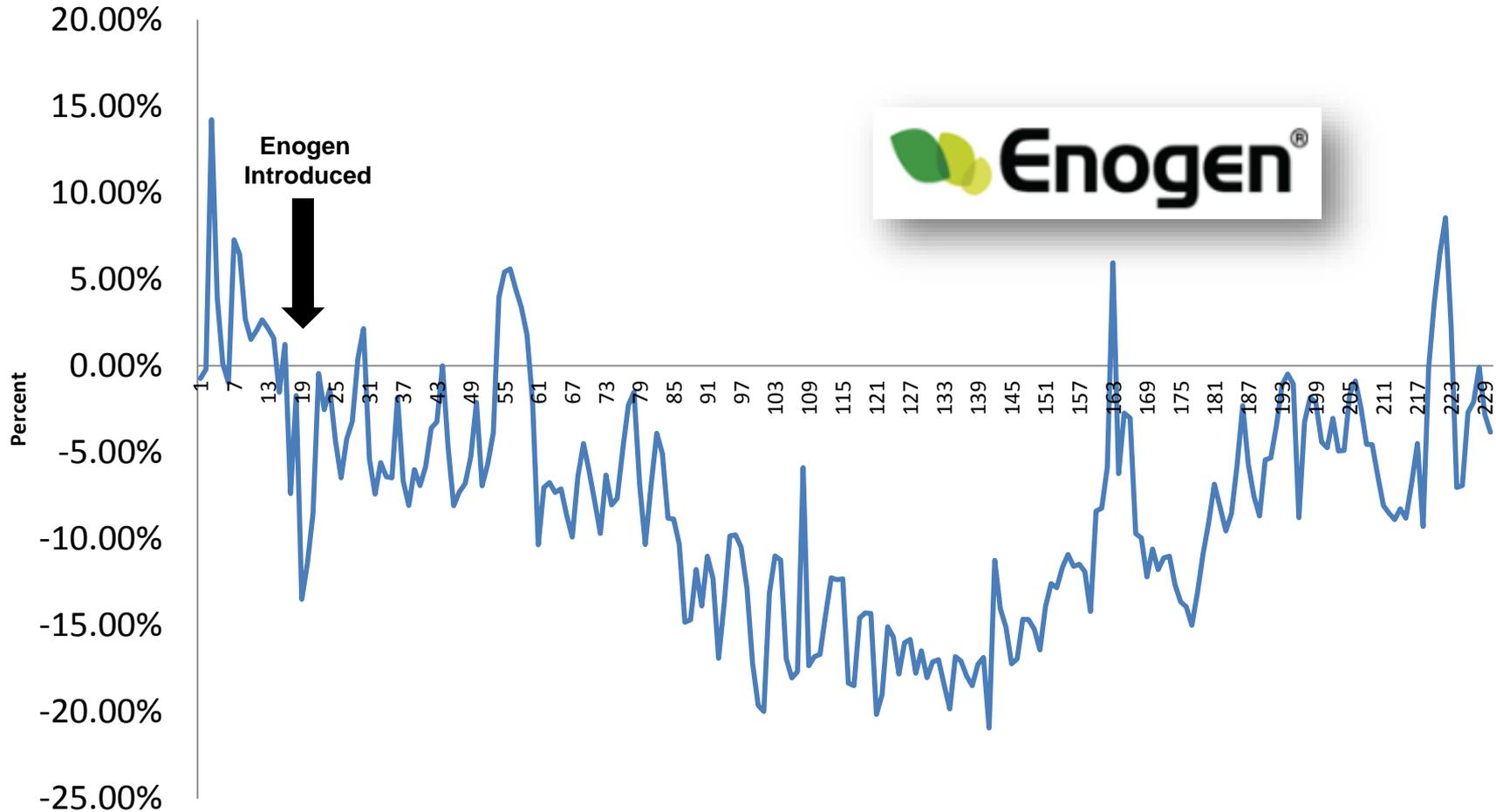
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# Enogen Demonstrates a Reduction in Natural Gas Use

## BTU's/Gal



\*2014 Enogen Trial with Vogelbusch-75mgpy Plant Type.

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# Enogen Corn is More Than Just Replacing Liquid Alpha Amylase Enzyme



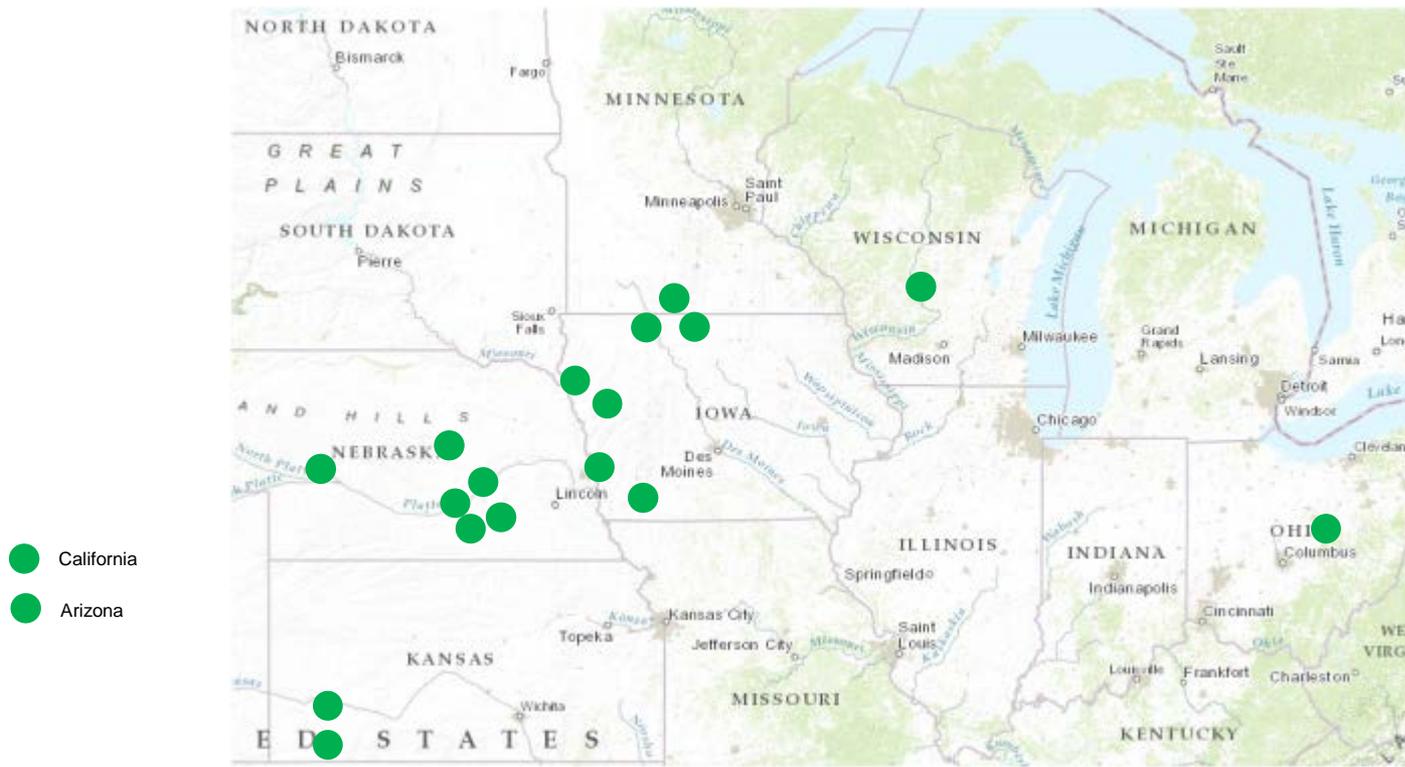
## Potential benefits at ethanol plant:

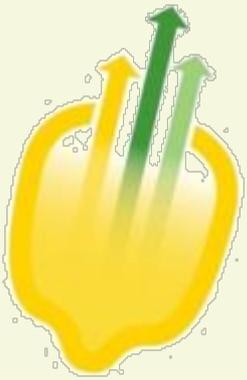
- ✓ **Processing flexibility**
- ✓ **Reduced energy and water use**
- ✓ **Reduced chemical usage**
- ✓ **Increased throughput and yield potential**
- ✓ **Reduced maintenance and labor**



# Enogen Footprint

***In 2016, Syngenta is working with 19 ethanol plants in 8 states to deliver more than 1.4 billion gallons.***





# Cellerate™

## Process Technology



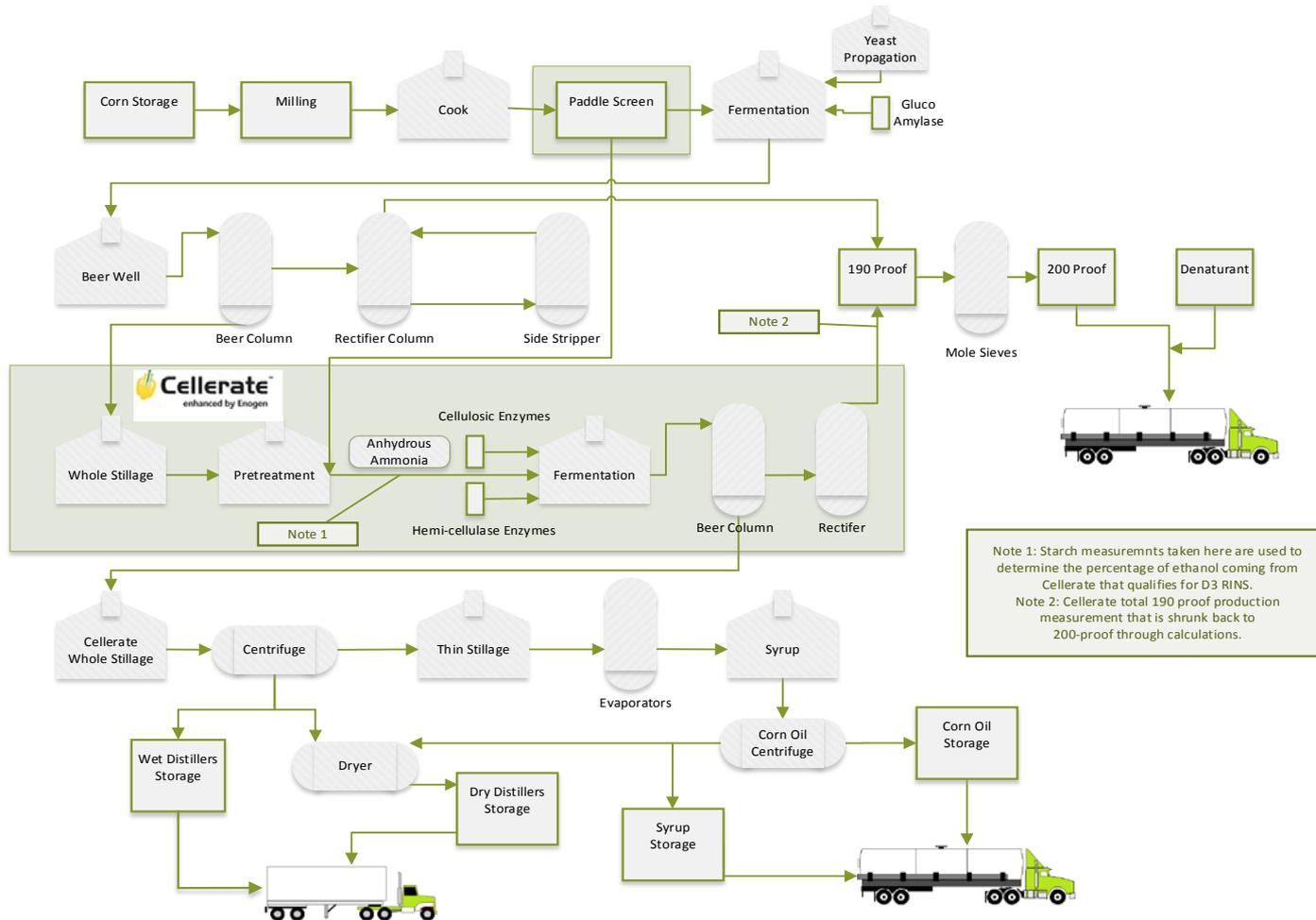
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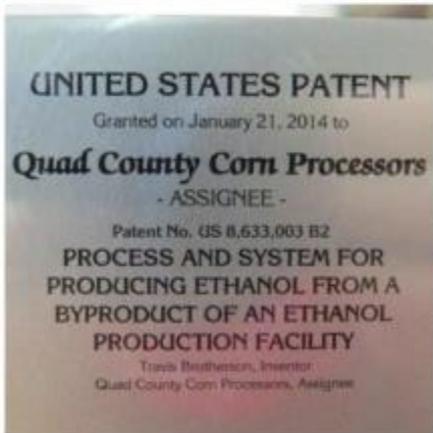
TM

# Cellerate™ Process Flow at Quad County Corn Processors



Note 1: Starch measurements taken here are used to determine the percentage of ethanol coming from Cellerate that qualifies for D3 RINS.  
 Note 2: Cellerate total 190 proof production measurement that is shrunk back to 200-proof through calculations.

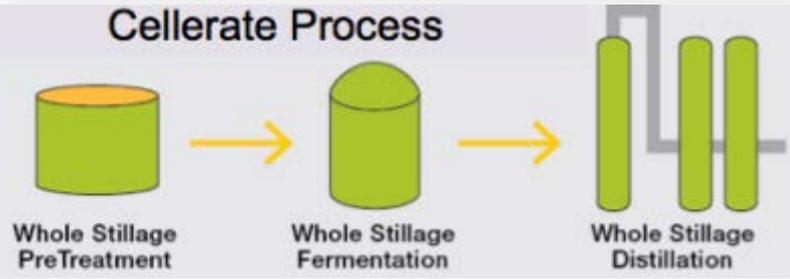
# Cellerate™: Milestones & Accomplishments



- July 2014: QCCP produced first cellulosic gallons in Iowa.
- October 2014: Approved by EPA to generate D3 RIN's.
- Eco-Engineers QAP program approved by EPA.
- April 2015: QCCP hits million-gallon cellulosic milestone.
- March 2016: 3 million D3 RINS produced.
- Performance results achieved to date:
  - 14% throughput increase
  - Total plant yield (gallons/bushel)
    - 2.89 (undenatured)
    - 2.95 (denatured)
  - Oil yield 0.97 lbs/bushel
  - DDG Protein 38% to 40%\*

\*33.5-36% as is basis

# Cellerate™ Enhanced By Enogen® is a Convenient Way to Capture More Value at Your Plant



- Cellerate + Enogen is able to provide:
  - additional throughput
  - higher yield
  - cellulosic ethanol
  - increased corn oil
  - enhance co-products at less cost per gallon
- QCCP invested \$9 million to install Equipment at its 40 MGPY corn starch plant but your plant may require more or less investment.
  - This is less than (50%) of new starch ethanol gallon production.

# Additional Value Areas From Cellerate™ That are In-Development

## Incremental Feed Value from DDG's

- Digestibility study conducted by Danisco on poultry demonstrated \$72 per ton value above DDG's in a least cost ration.
- Expected premium market opportunities:
  - Other monogastric species
  - Dairy
  - Export markets
- Increased protein levels are expected with incremental oil extraction capabilities.
- Initial test results did not indicate increased beef performance

## Low Carbon CARB index value and future opportunities with Hemi-Cellulose

- Enogen enhanced throughput values should allow for lower CI valuation for Cellerate.
- Expect a CI index of 0-44 depending on how indirect land use and additional corn oil from Cellerate are considered. CI on Cellerate gallons only.
- Currently in discussions with five yeast companies to evaluate their C-5 yeast. FDA approvals are pending



# Enogen Enables Natural Gas and Electricity Savings Leading to Reduced CI Score for Ethanol Plants

Enogen's unique ability to reduce viscosity enables ethanol plants to increase solid loading which leads to reductions in natural gas and electricity.

- Higher solids content in corn mash and higher EtOH concentration in beer lead to reduced heating, evaporation, distillation energy loads.
  - 13% reduction in steam usage.
  - 14% reduction in electricity loads on pumps.

For Dried DDGs, Enogen can reduce the FTW (field to wheels) score from 98.4 to 86.05 gCO<sub>2</sub>e / MJ.

For Wet DDGs, Enogen can reduce the FTW score from 90.1 to 78.1 gCO<sub>2</sub>e / MJ.

# Carbon Intensity Modeling Results

Carbon Intensity by Phase	Units	ETHC004 Midwest; Dry Mill; Dry DGS, NG	ETHC008 Midwest; Dry Mill; Wet DGS; NG	Enogen + Corn (Dry DGS) Midwest: Modern Dry Mill; Dry DGS; NG	Enogen +Corn (wet DGS) Midwest: Modern Dry Mill; Wet DGS; NG
Agricultural Production, plus ILUC	gCO2e / MJ			56.50	56.50
Ethanol Processing, Combustion & Denaturant	gCO2e / MJ			29.55	21.60
Total FTW	gCO2e / MJ	98.40	90.10	<b>86.05</b>	<b>78.10</b>
Reduction from Reference	gCO2e / MJ			12.35	12.00

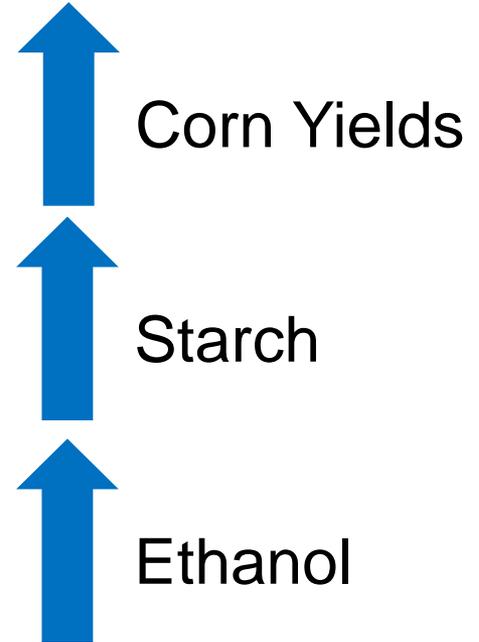
**-13%**

**-14%**

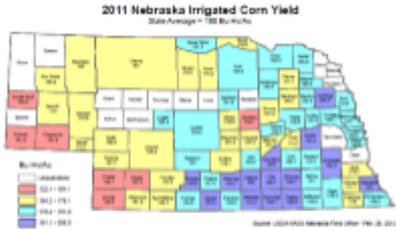
# How do improve GHG reduction on the farm?

## Ethanol Grower Advantage

- Targeted toward production efficiencies
- Higher yields on the farm



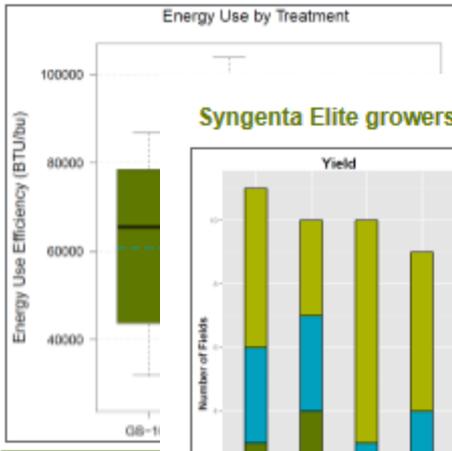
### 2011 Background - NASS Statistics for Nebraska & Kansas irrigated corn



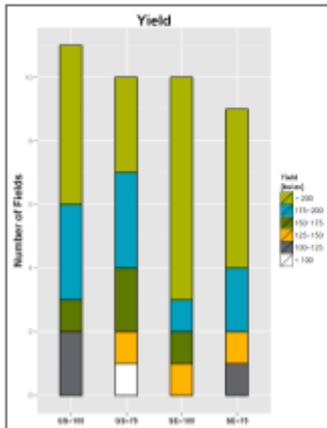
- Nebraska growers demonstrated another banner production year with normal to excess precipitation.

- Kansas 20-30% Irrigated
- Irrigation significant

### Boosting energy efficiency with Syngenta Elite



### Syngenta Elite growers excel against the competition!



Syngenta Elite growers produced more fields with 200 bu/A or more in both irrigation scenarios.

Higher yielding fields are more prevalent with the programs receiving irrigation to account for 100% of the water lost to ET.

Central Plains irrigated corn has a 40% improvement in land use efficiency compared to rainfed corn production in this area.

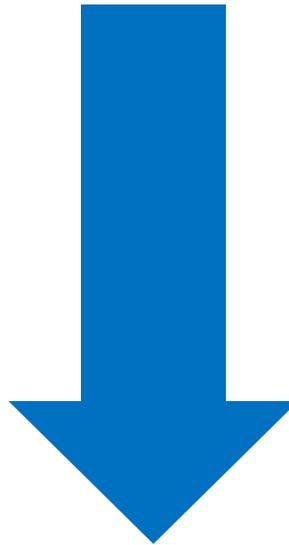
Opportunities to maximize land use efficiency with increased plant populations.

# Ethanol Grower Advantage

***Preliminary results indicate general trends but clearly there is a need to assess the field prints for participants and collect information for multiple years.***

Efficiency Indicator
Water Use
Soil Loss
Nitrogen Use
Land Use
GHG Emissions
Energy
Soil Conditioning

Most Efficient



Least Efficient

Growers should continue to fine tune their field operations to maximize the triple threat to productivity, profitability and environmental performance.

# What are the accrued benefits of the Ethanol Grower Advantage? Increasing productivity, profitability and resource efficiency.

11%



improvement in Land use Efficiency

25%



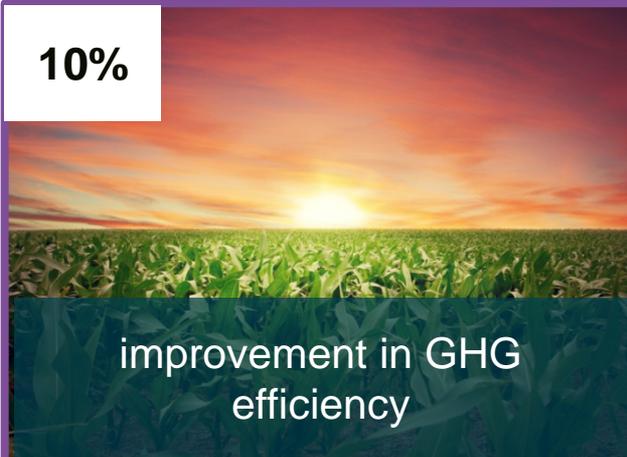
improvement in water use efficiency under limited irrigation

7%



improvement in energy use efficiency

10%



improvement in GHG efficiency

14%



improvement in soil conservation efficiency

12%



improvement in nitrogen use efficiency

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