

Biological feedstocks

What does industry need?

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What does industry **want**?

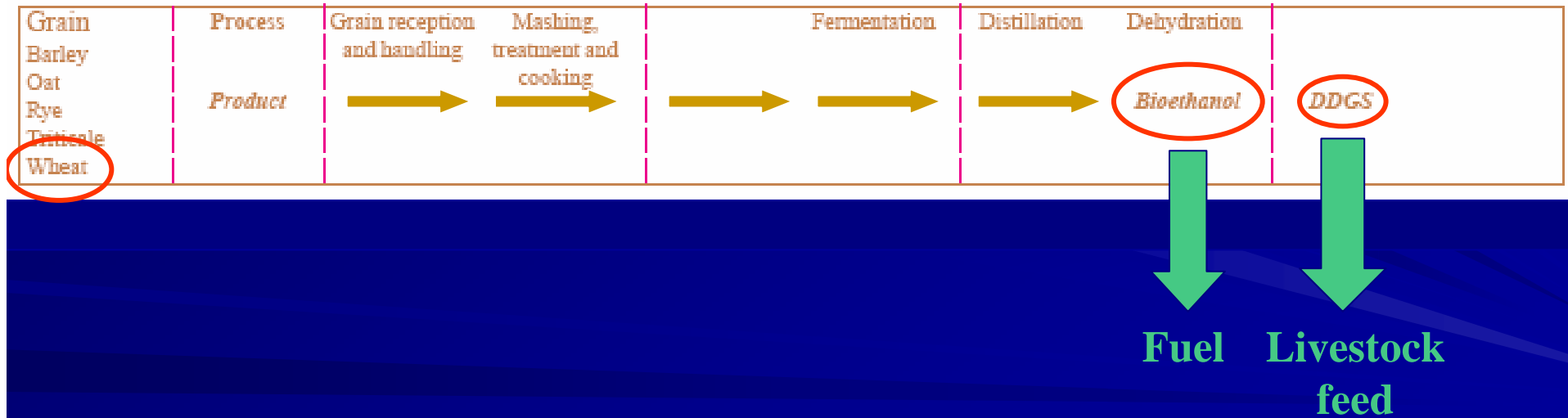
- High yielding, high starch content wheat
- Those profiting primarily from the sale of bioethanol, and the sale DDGS as a by-product, cite these issues exclusively

What does industry **need**?

- There has been little discussion around
 - How the industry may evolve and consolidate
 - Whether specific feedstock traits may be of value
 - Whether crops other than wheat may be more suitable as bioethanol feedstocks
 - Value-added propositions

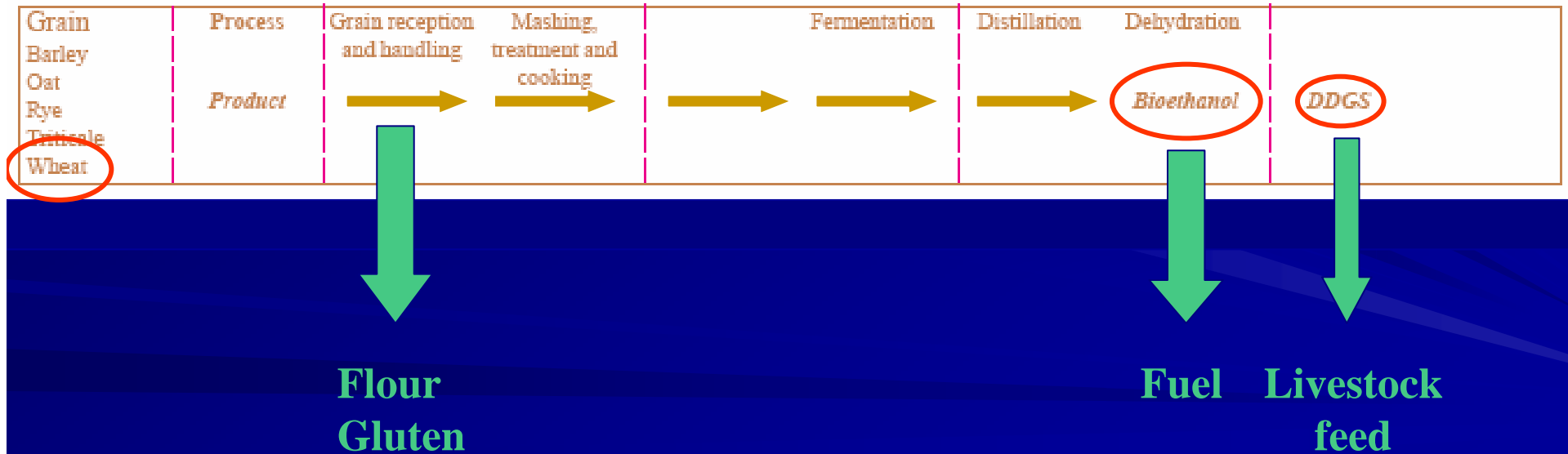
A distillers view of the value chain

The basic model



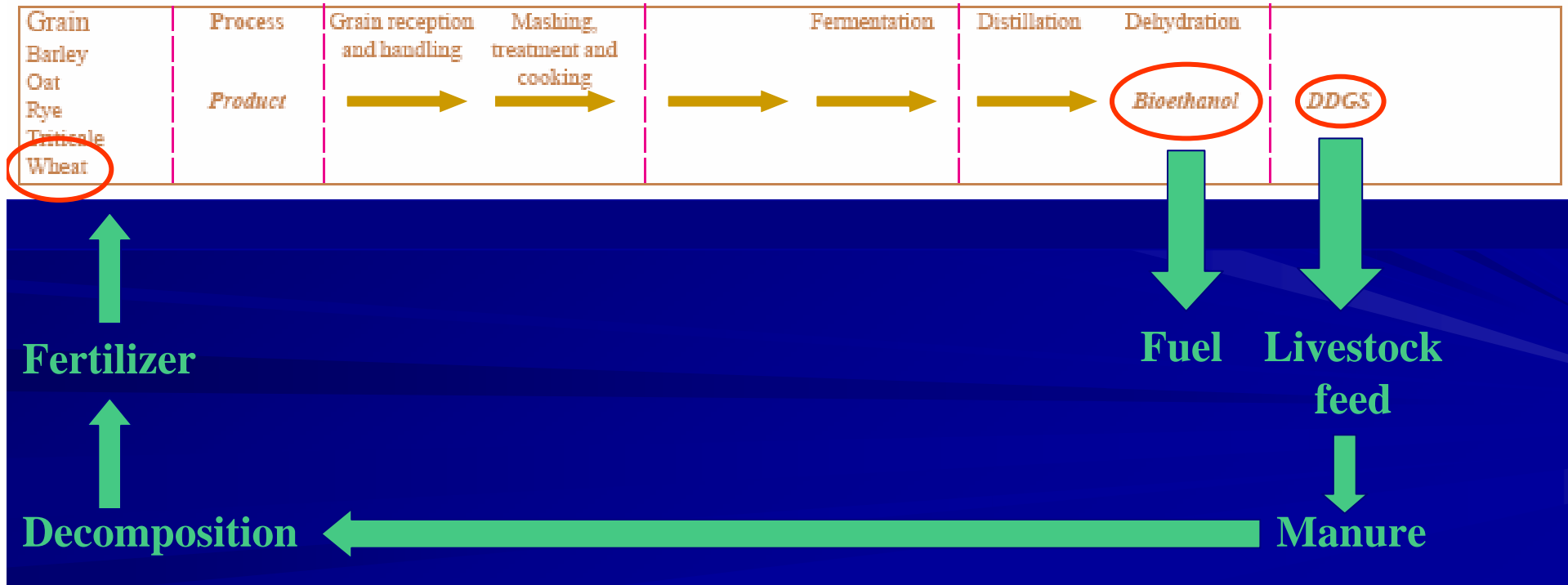
A distillers view of the value chain

The flour/gluten model

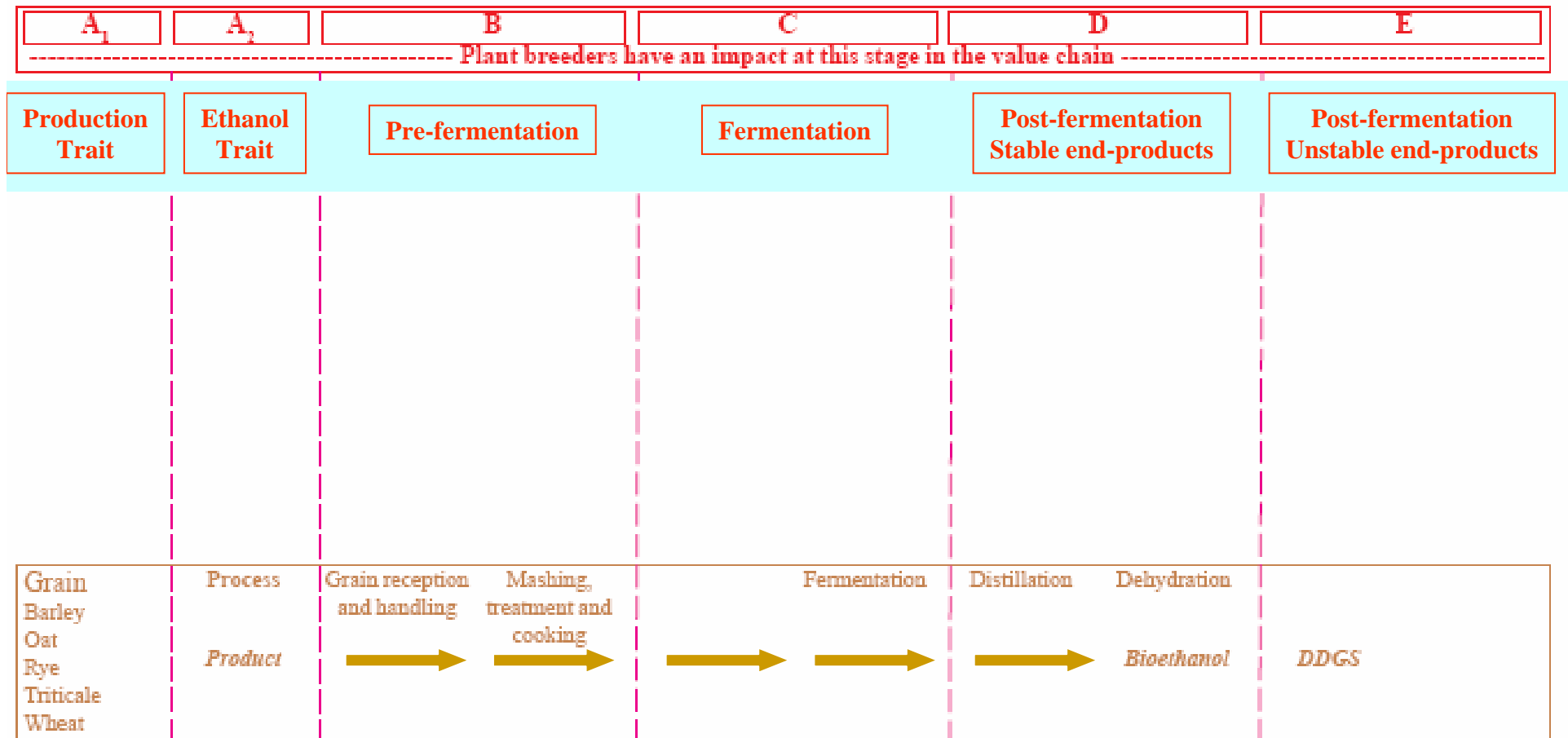


A distillers view of the value chain

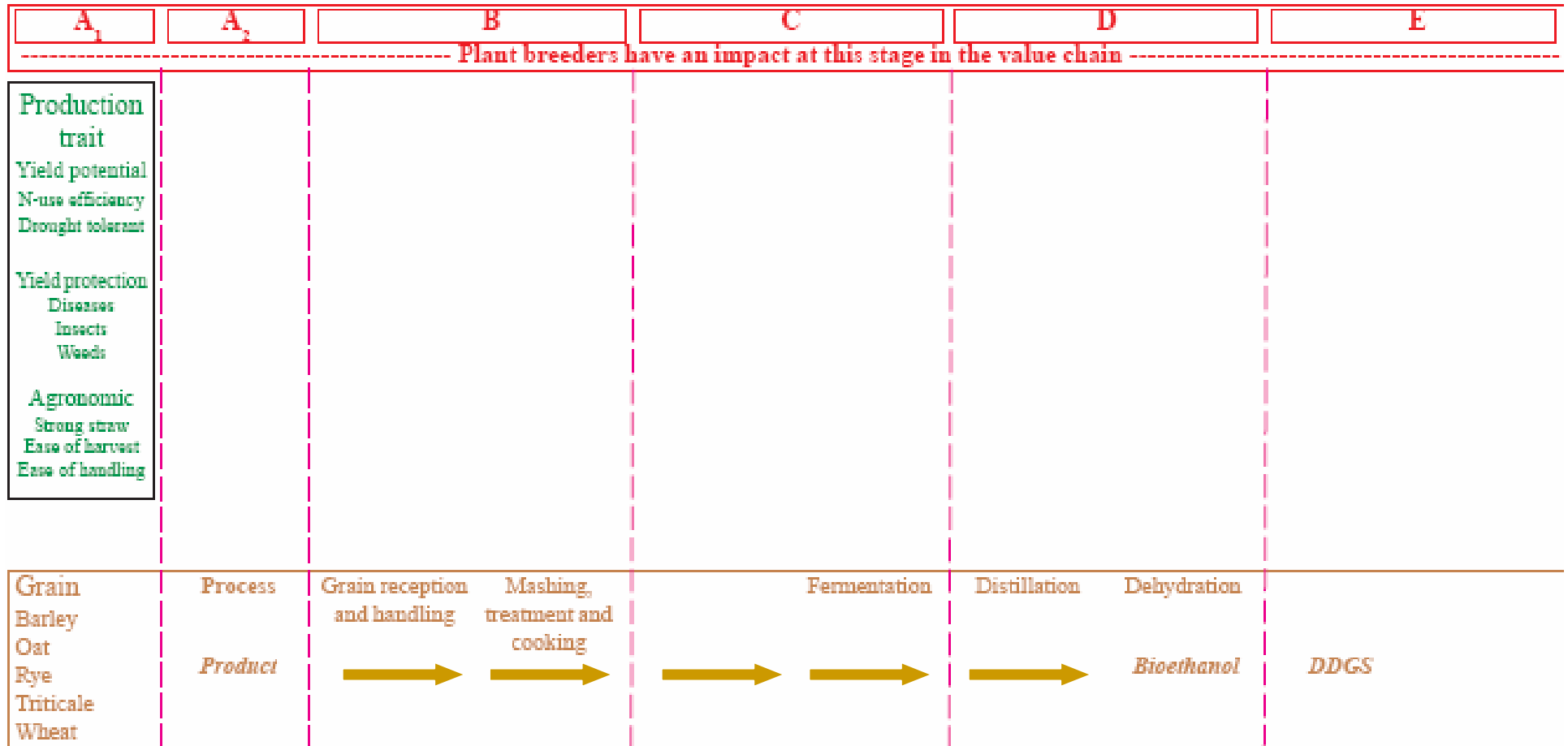
The livestock model



Where can plant breeders add value?



Production trait



Fractionation

- For bioethanol plants that derive an income stream from a co-product, wheat fractionation may occur before fermentation and distillation, increasing the starch content of the flour
- The fractionation operation concentrates the starch and the starch content of the raw grain is less of an issue






Fractionation and the value of starch content

- How much do we want to invest in raising the starch content of wheat if we could fractionate wheat before distillation?
- Pre-fermentation milling reduces the incidence of fermentation inhibitors and increases starch concentration in the feedstock
 - Increasing efficiency of ethanol production
 - Enhancing the conversion of starch to ethanol
 - Increasing ethanol yield
- Some proprietary processes can
 - Reduce the levels of fermentation inhibitors from 35 to 7 percent
 - Increase the yield of ethanol by 3 percent (corn)
- This milling system could add about \$15-16M to the cost of a \$130M facility
 - Terra Grain Fuels facility, Belle Plaine, SK.

Pre-fermentation

| A ₁ | A ₂ | B | | C | D | E |
|--|---|--|-------------------------------------|--|-------------------|--|
| ----- Plant breeders have an impact at this stage in the value chain ----- | | | | | | |
| Production trait Yield potential N-use efficiency Drought tolerant Yield protection Diseases Insects Weeds Agronomic Strong straw Ease of harvest Ease of handling | Ethanol trait Bioethanol High starch High total fermentables Hullless grain No Fusarium No Ergot High test weight | Pre-fermentation Extract value-added components Volatile compounds Oryzenol Phytoestrogen Pullulan Tocopherol Tocotrienol Beta-carotene Vitamin E Beta-glucan Gluten | | Carboxypeptidase Fatty acid Lectin Cinnamate Avenanthramide Hydroxycinnamic acid Oil Glyceride Phytate | | |
| Grain Barley Oat Rye Triticale Wheat | Process Product | Grain reception and handling → | Mashing, treatment and cooking → | Fermentation → | Distillation → | Dehydration → Bioethanol DDGS |

Post-fermentation Stable end-products

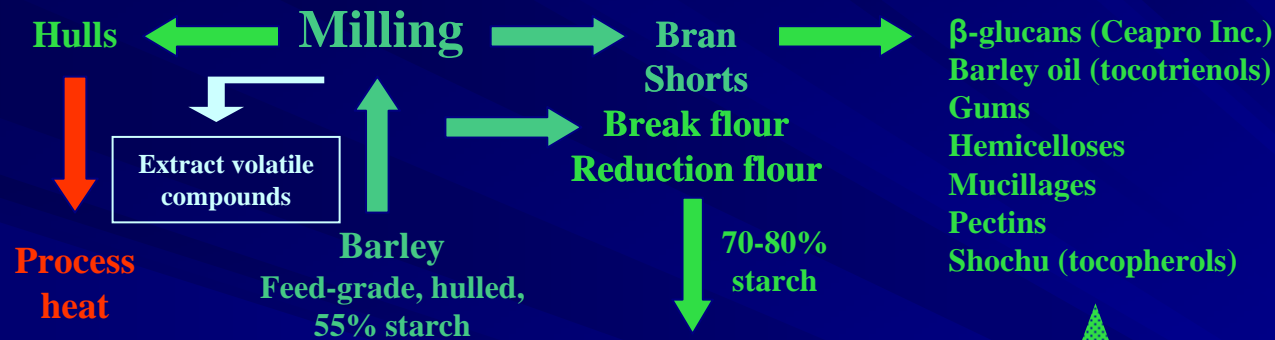
| A ₁ | A ₂ | B | | C | D | | E |
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| Grain Barley Oat Rye Triticale Wheat | Process Product | Grain reception and handling  | Mashing, treatment and cooking  | Fermentation   | | Distillation  | Dehydration Bioethanol DDGS |

Post-fermentation Unstable end-products

| | A ₁ | A ₂ | B | | C | D | | E |
|--|---|---|--|--|---|---|---|---|
| ----- Plant breeders have an impact at this stage in the value chain ----- | | | | | | | | |
| Production trait | Ethanol trait | Pre-fermentation | | Fermentation | | Post-fermentation Stable end-products | | Post-fermentation Unstable end-products |
| Yield potential N-use efficiency Drought tolerant | Bioethanol High starch High total fermentables Hullless grain No Fusarium No Ergot High test weight | Extract value-added components | | Attributes - bioethanol | | Extract value-added components | | Value-added DDGS |
| Yield protection Diseases Insects Weeds | | Volatile compounds Oryzenol Phytoestrogen Palladin Tocopherol Tocotrienol Beta-carotene Vitamin E Beta-glucan Gluten | Carboxypeptidase Fatty acid Lectin Cinnamate Avenanthramide Hydroxycinnamic acid Oil Glycoside Phytate | Low viscosity Low level of unfermentables Positive starch configuration High free-amino N content High level of disassembly into simple sugars | | Germ Protein Ash Phytate Glycerol Acetic acid Citric acid Lactic acid Residual starch Alkaloid | Lectin Lipid Xanthan Sterol Tannin Phospholipid Fiber Amino acid Gum Phenolic acid | DDGS with highly digestible bran DDGS with low phytate levels DDGS with low variability from batch-to-batch and from facility-to-facility DDGS with high oil content DDGS with high levels of dietary protein DDGS with high food functionality |
| Agronomic Strong straw Ease of harvest Ease of handling | | | | Extract CO ₂ | | | | |
| Grain Barley Oat Rye Triticale Wheat | Process | Grain reception and handling | Mashing, treatment and cooking | Fermentation | | Distillation | Dehydration | |
| | Product | → | → | → | → | → | Bioethanol | DDGS |

A distillers view of the value chain

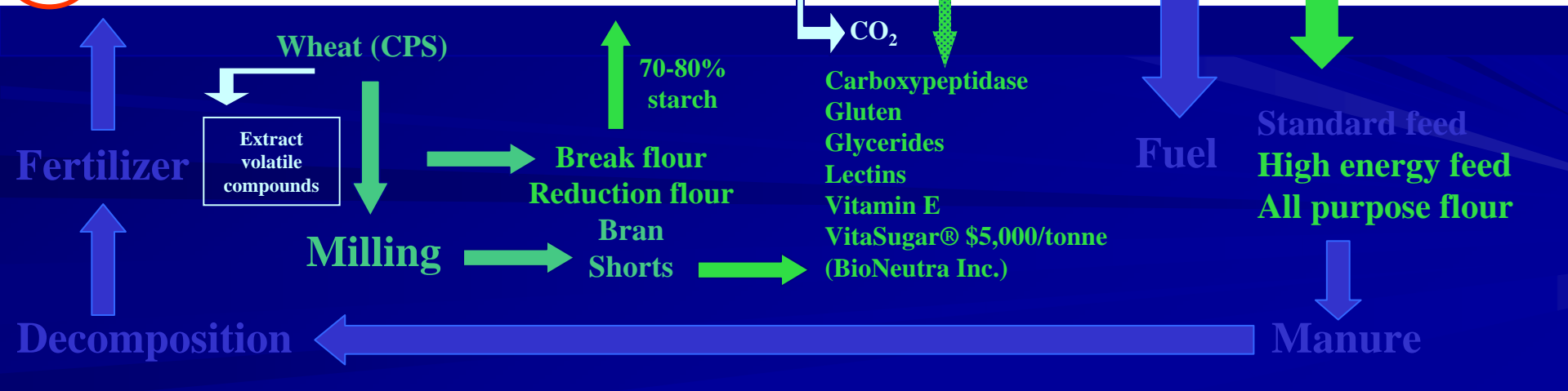
One model of the future



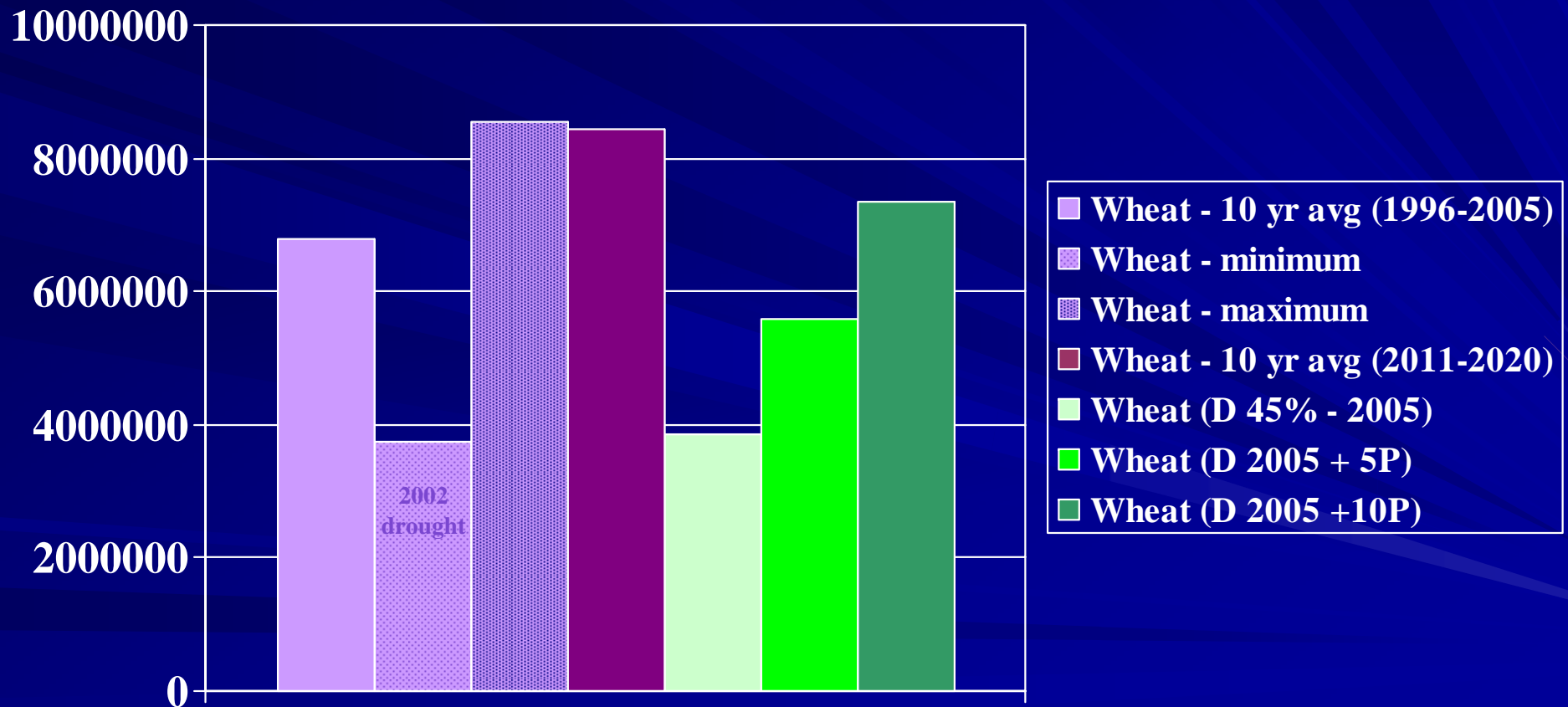
Barley in excess of 15% of total feedstock (by weight) requires the addition of enzymes at a cost of \$750,000/year of operation

Total cost of enzymes is typically \$4M/year

| Grains | Process | Grain reception and handling | Mashing, treatment and cooking | Fermentation | Distillation | Dehydration | Product |
|---------------|---------|------------------------------|--------------------------------|--------------|--------------|-------------|------------------------------------|
| Barley 15% | | → | → | → | → | → | High energy DDGS (high oil barley) |
| Rye | | | | | | | Bioethanol |
| Triticale 85% | | | | | | | |
| Wheat | | | | | | | |

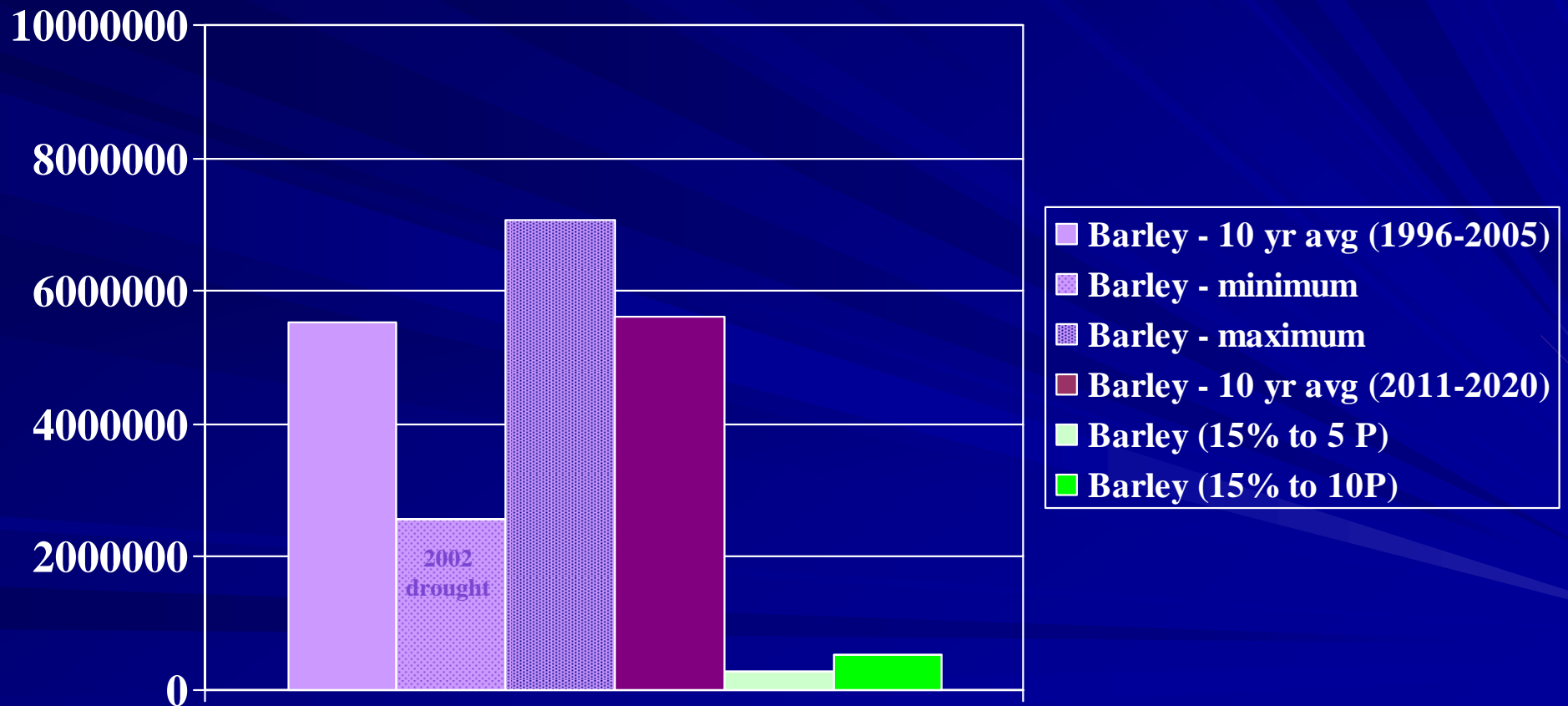


Alberta wheat Production and consumption (tonnes)



Alberta barley

Production and consumption (tonnes)



Alberta canola for biodiesel

Production and consumption (tonnes)

