



CELLULOSIC BIOFUELS: FROM PILOT TO DEMO TO COMMERCIAL

TREVOR MORGAN, NOVOZYMES
Ethanol Producers and Consumers
Missoula, Montana
June 28, 2010

RETHINKING FUEL

- The world is projected to **increase energy use by 55%** from 2005 to 2030
- Transport is the second largest energy user and **the largest oil user**
- By 2050 there will be an estimated 2.3 billion additional cars worldwide – **1.9 billion of these in developing countries**
- Improved mileage and alternative vehicles will **limit but not eliminate** the need for liquid transportation fuels

OUR COMMITMENT TO THE ETHANOL INDUSTRY BEGINS WITH OUR GLOBAL EFFORTS AND FOCUS

- Leading provider of enzymes for ethanol in all regions where we operate
- Broad insight into cellulosic ethanol – we are working on many feedstocks and technologies
- Unprecedented effort with more than 150 people dedicated to Novozymes' cellulosic ethanol work
- Global R&D focus on cellulosic ethanol



Novozymes' research, development and production locations

CELLULOSIC ETHANOL IS MOVING TO COMMERCIAL SCALE

Phase 1

2000 – 2008

Key stakeholders

- R&D/universities
- Equipment manufacturers
- Biotechnology industry
- Government

Lab scale

- Enzyme and process R&D
- Significant reduction in enzyme cost and overall production cost
- First pilot plants in the US and Europe – several running continuously

Phase 2

2009 – 2010

Key stakeholders

- Ethanol industry
- Engineering/construction
- Biotechnology industry
- Government

Pilot scale

- Further enzyme and process R&D
- Pilot plants using bagasse being built in Brazil
- Demonstration-scale plants being built in the US, Europe and China

Phase 3

2010 – 2011

Key stakeholders

- Ethanol industry
- Engineering/design
- Banks
- Government

Demonstration scale

- Bagasse demonstration plants built in Brazil
- Enzyme for commercial-scale production launched
- Demonstration-scale plants operating
- Commercial-scale plants being built

Phase 4

2012 – onwards

Key stakeholders

- Ethanol industry
- Engineering/design
- Banks
- Government

Commercial scale

- Large-scale demand for cellulosic ethanol in the US and Europe
- Build-up of production capacity in Brazil

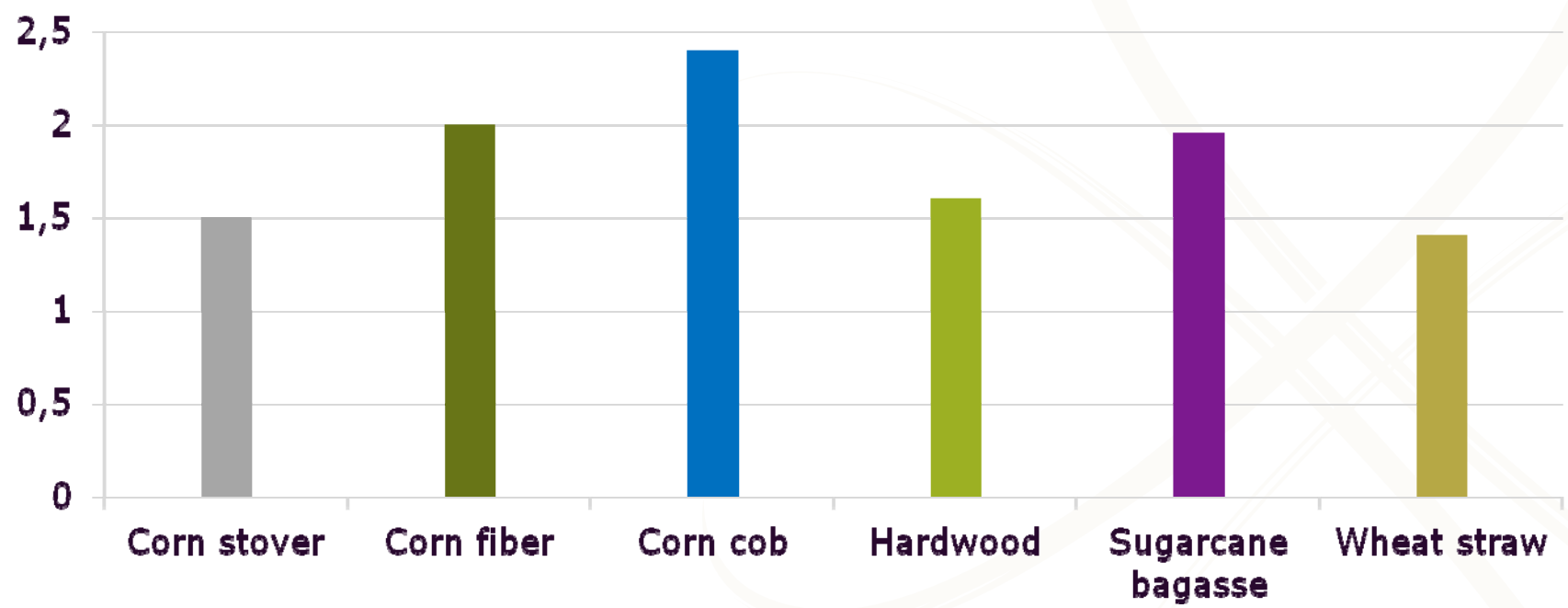
NOVOZYMES CELLIC[®] CTEC2 **DELIVERING ON OUR PROMISE**



The first commercially viable enzyme for cellulosic ethanol

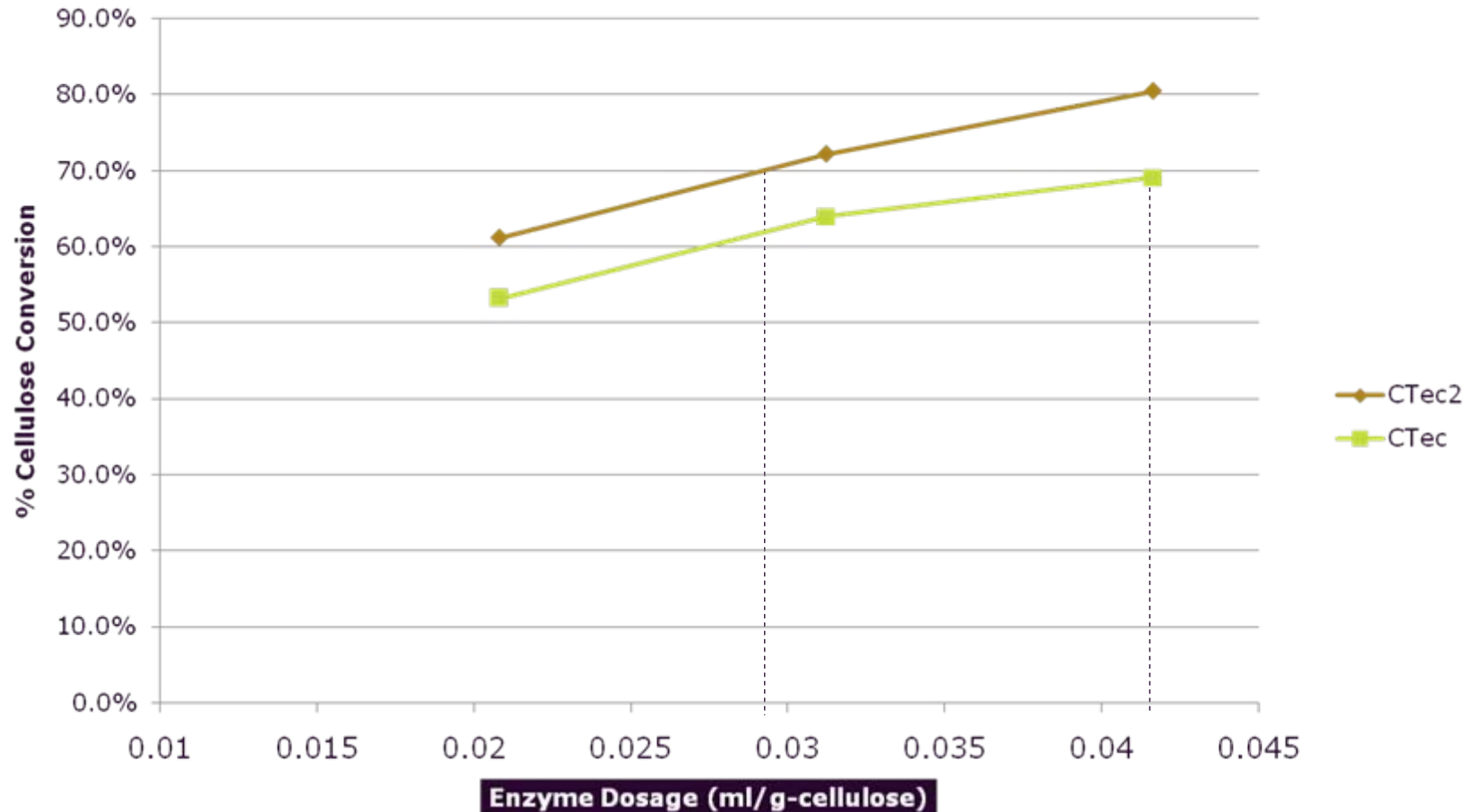
SIGNIFICANT PERFORMANCE IMPROVEMENT WITH CELLIC[®] CTEC2

Relative enzyme dose reduction - Cellic CTEC2 to Cellic CTEC

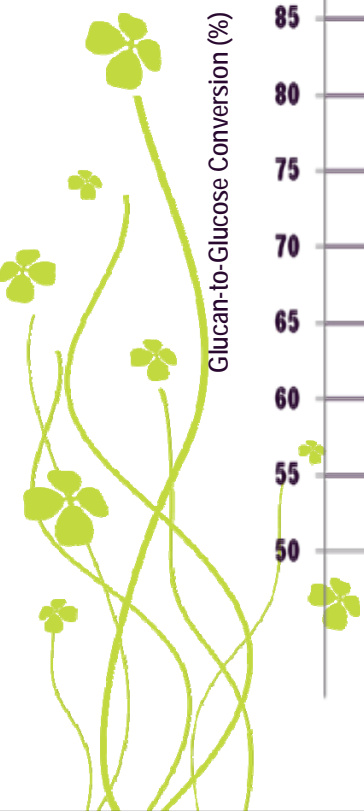
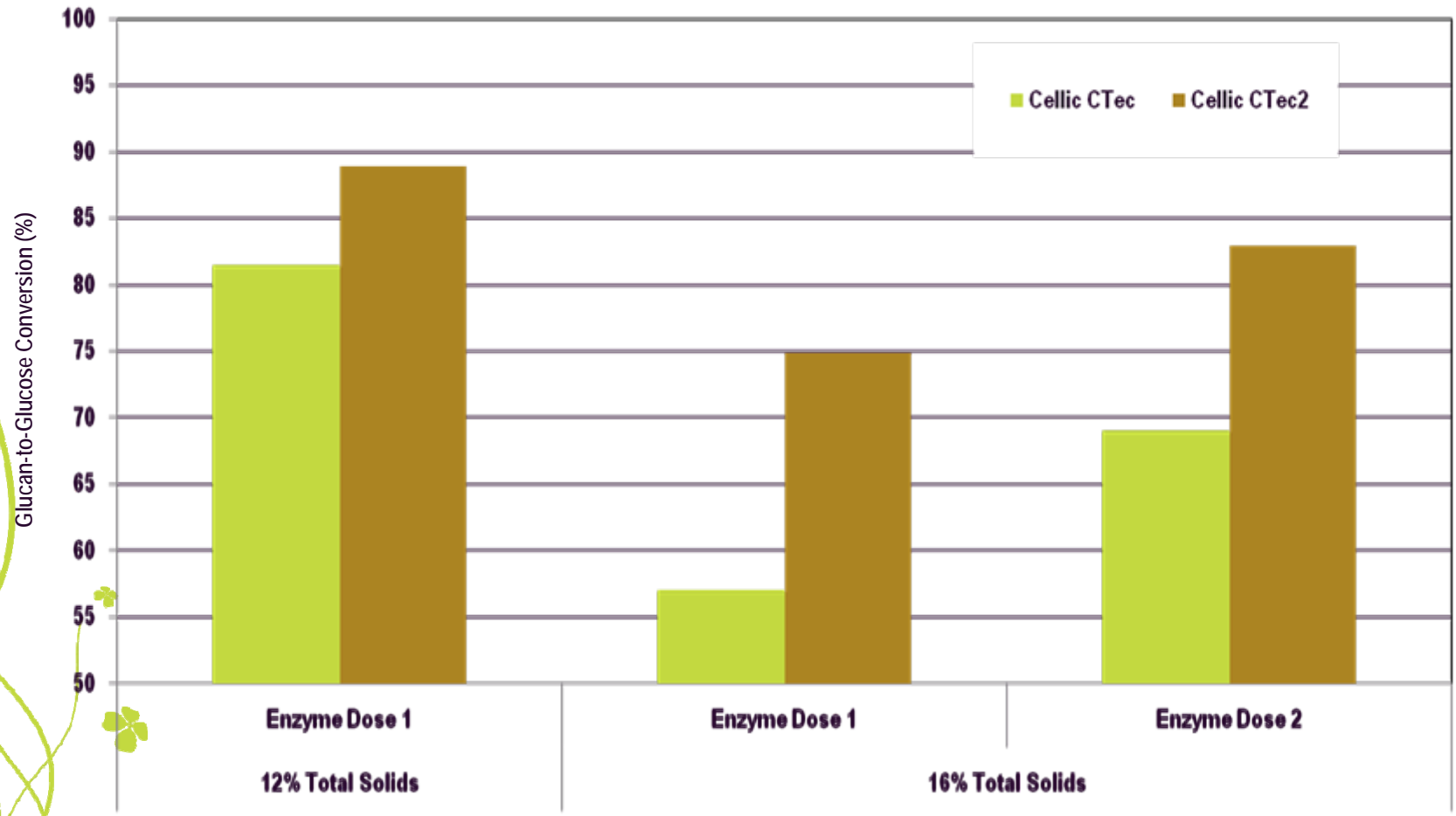


COMMERCIALLY RELEVANT ENZYME DOSING

Hydrolysis of unwashed NREL PCS, 20% TS, 8-days



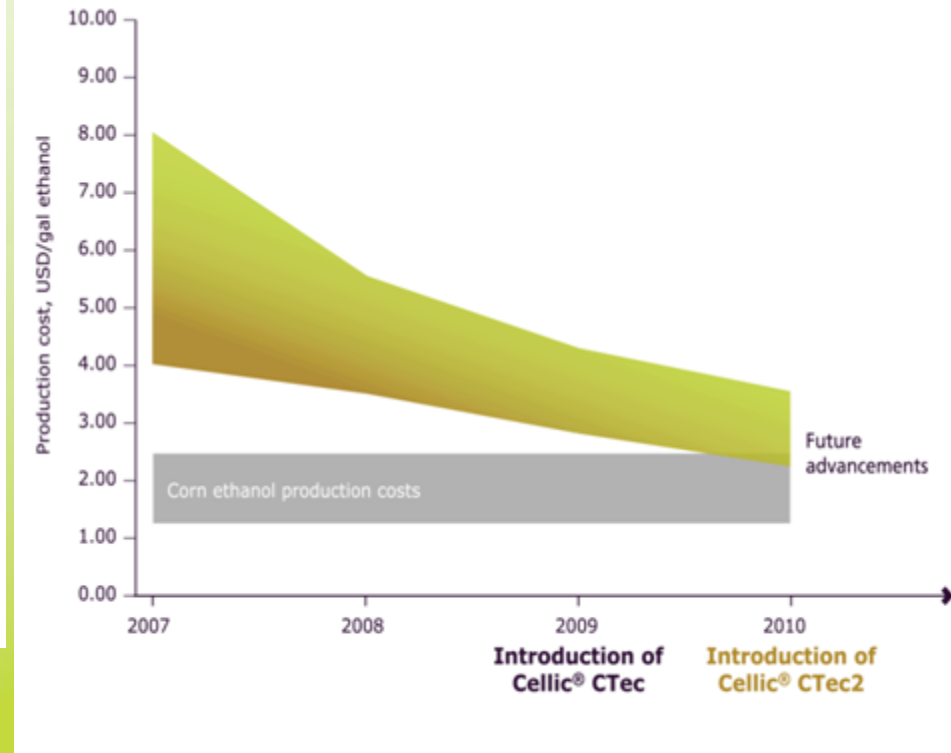
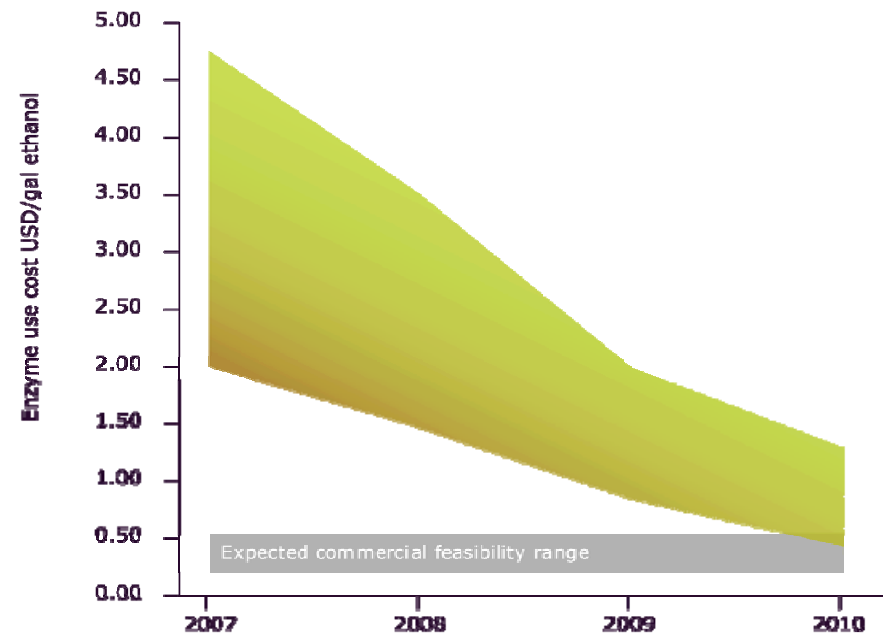
INCREASED PERFORMANCE AT HIGHER TOTAL SOLIDS



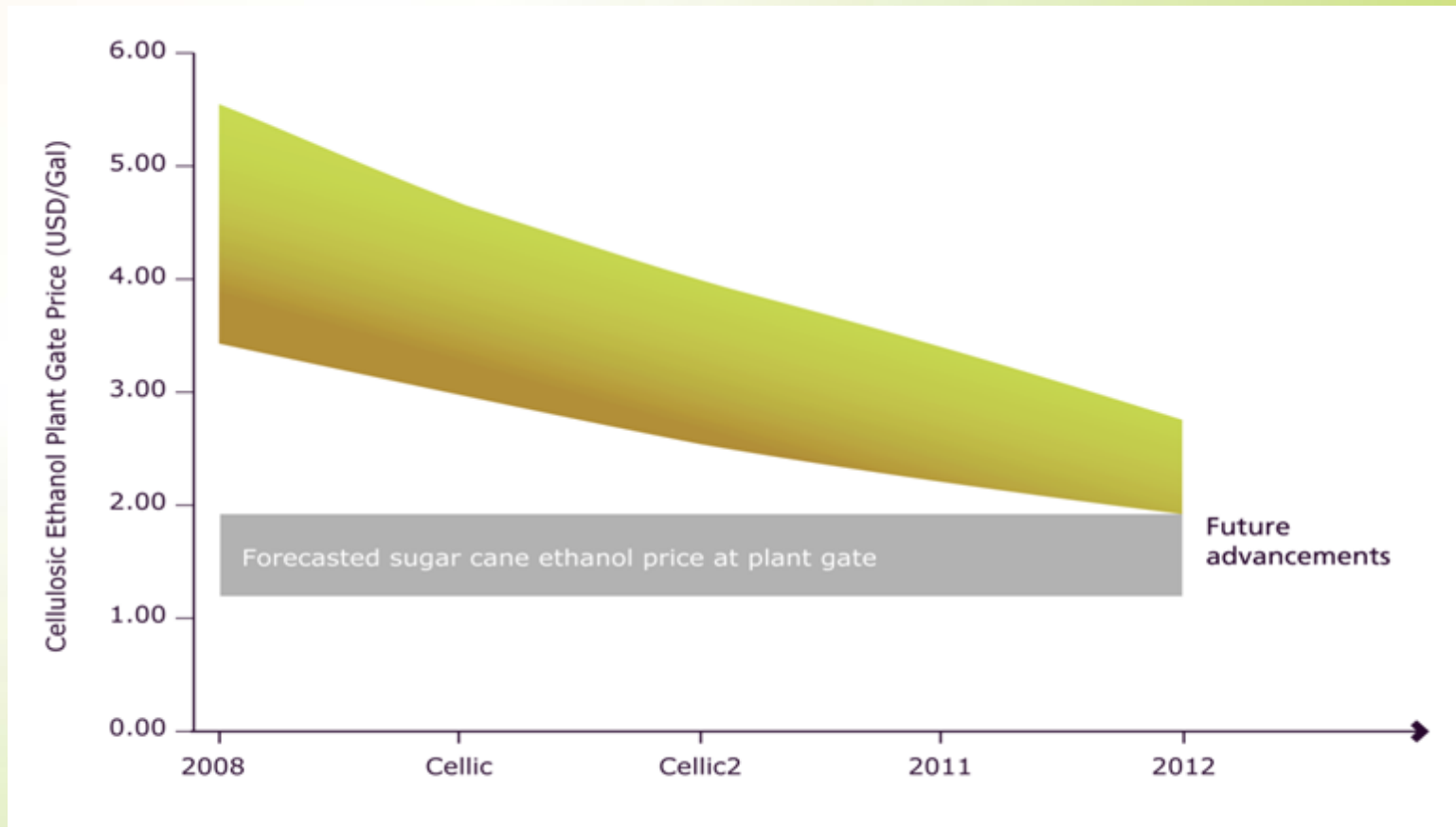
Novozymes' Cellic® product family is enabling commercial viability

Enzyme costs are becoming a smaller and smaller percentage of the total process costs

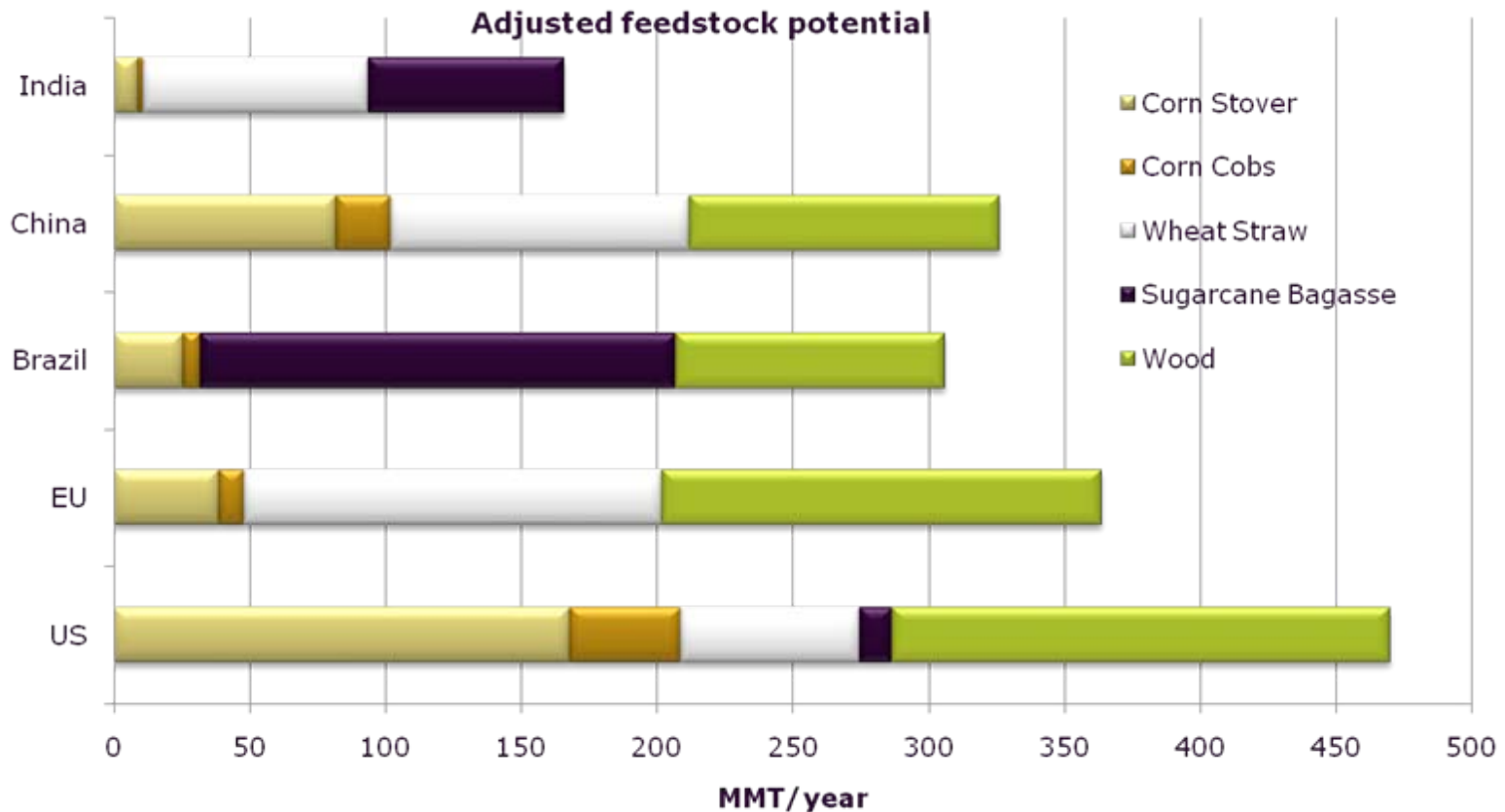
Production costs are coming in line with corn based ethanol costs



Cellulosic ethanol is becoming a reality in regions outside North America



THERE IS LARGE POTENTIAL FOR MANY CELLULOSIC ETHANOL FEEDSTOCK ALTERNATIVES AND TECHNOLOGIES



OUR PARTNERS ARE PROGRESSING



FEEDSTOCK HANDLING PARTNER: **INBICON**



Achievements:

- Handles 1.2 Mtons/year of biomass for heat and power generation
- 35% lower enzyme use cost achieved through the use of Cellic[®] CTec2 and process optimization
- With additional process optimization opportunities identified, we will realize a 65% decrease in enzyme use costs by 2012



About Inbicon:

- 5.25 MLY demo plant in Denmark opened 2009
- Pilot plants since 2003
- Sells technology worldwide
- Low-investment proprietary process technology

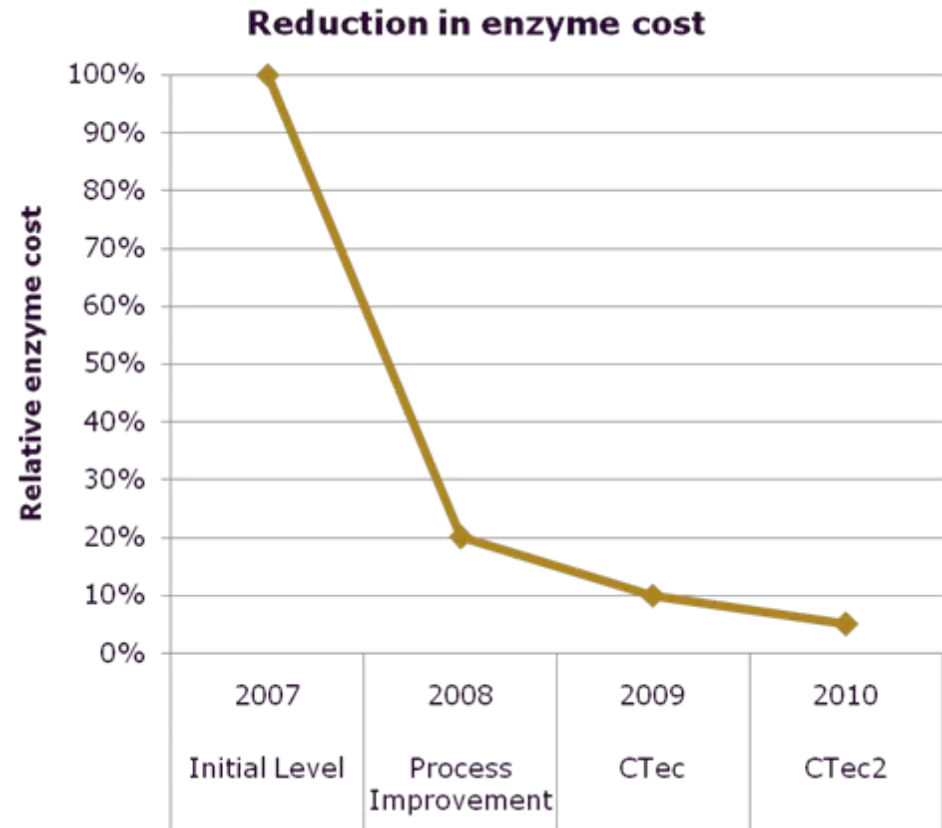
PROCESS INTEGRATION AND OPTIMIZATION PARTNER: **GREENFIELD ETHANOL**

Novozymes Cellic[®] CTec2

- 20x reduction in enzyme cost in three years
- Validated in 5-T hydrolysis reactor
- Two 50% reduction step changes from enzyme improvement
- 3 years with repeatable results at multiple scales

GreenField Ethanol

- Largest fuel ethanol producer in Canada
- R&D facility in Chatham, Ontario
- 1 ton/day pilot plant
- Focus on corn cob and screening other feedstocks

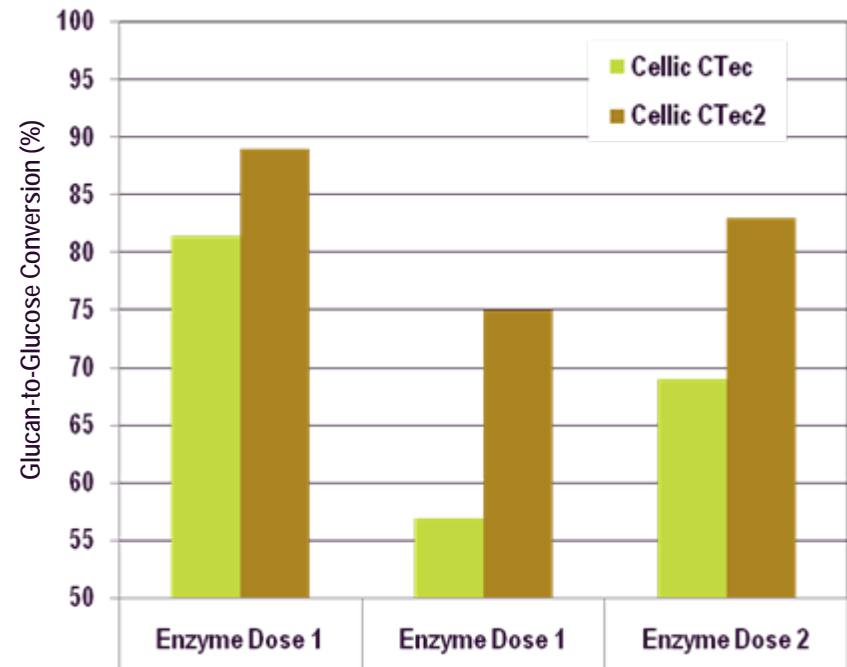


MOVING TO HIGHER TOTAL SOLIDS

PARTNER: **LIGNOL**

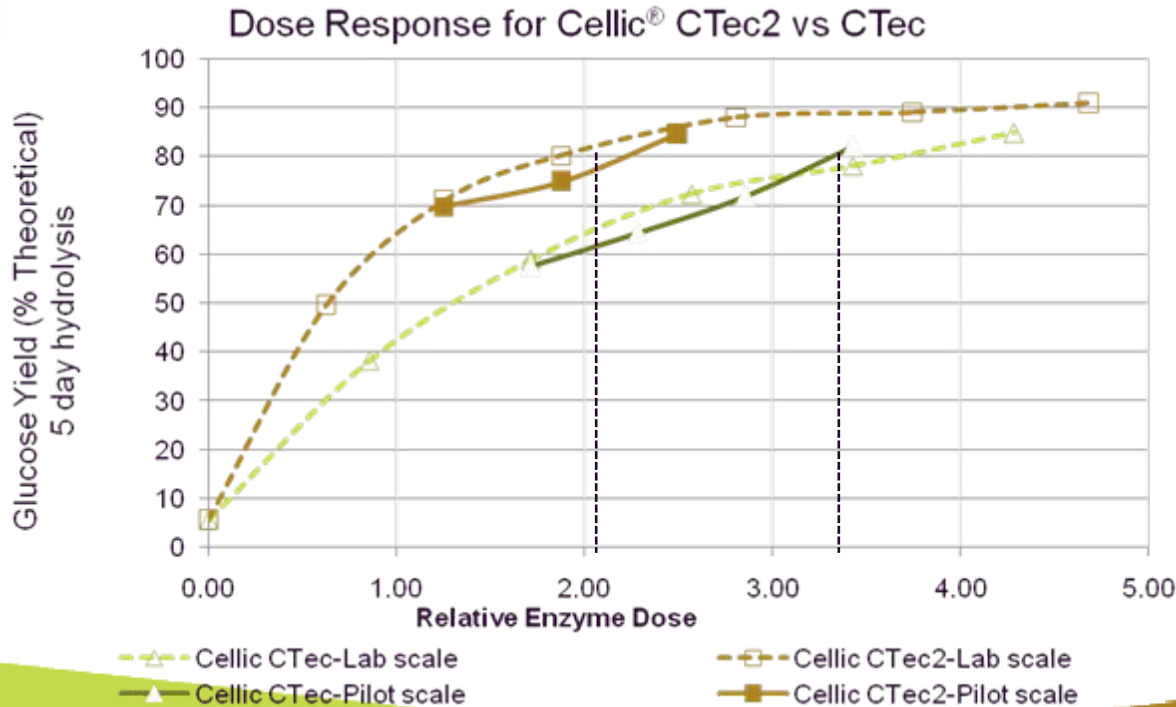
About Lignol:

- Integrated pilot plant
 - Upstream extraction of lignin and hemicellulose yields pretreated cellulose enriched biomass solids (~90%+)
 - Separation of biomass components into clean streams provides value-added products
- 20% reduction in enzyme costs in less than 4 months
 - Lower capital costs are reachable with increased performance at higher total solids
 - Higher conversion yields due to the ability to convert recalcitrant cellulose



SCALING UP PROCESS TECHNOLOGY

PARTNER: **POET**



About Poet:

- Biofuel industry leader
- Major effort to commercialize cellulosic ethanol – Project Liberty
- A history of innovative collaboration with Novozymes

- Testing demonstrates 1.8X reduction in enzyme dosage using Cellic CTec2
- Commercially viable enzyme use cost achieved through process improvements and new enzyme technology

NOVOZYMES IS LEADING THE WAY... ...TO A PROMISING FUTURE

- Novozymes Cellic[®] CTec2 is the first commercially viable product for cellulosic ethanol
- Our partners have proven technologies that they are scaling up to provide a viable liquid transport fuel – now
- Together with our partners, Novozymes is making cellulosic ethanol a commercial reality

READ MORE ABOUT HOW WE
ARE DEVELOPING TECHNOLOGY
TOGETHER WITH OUR
PARTNERS AT

www.bioenergy.novozymes.com

