

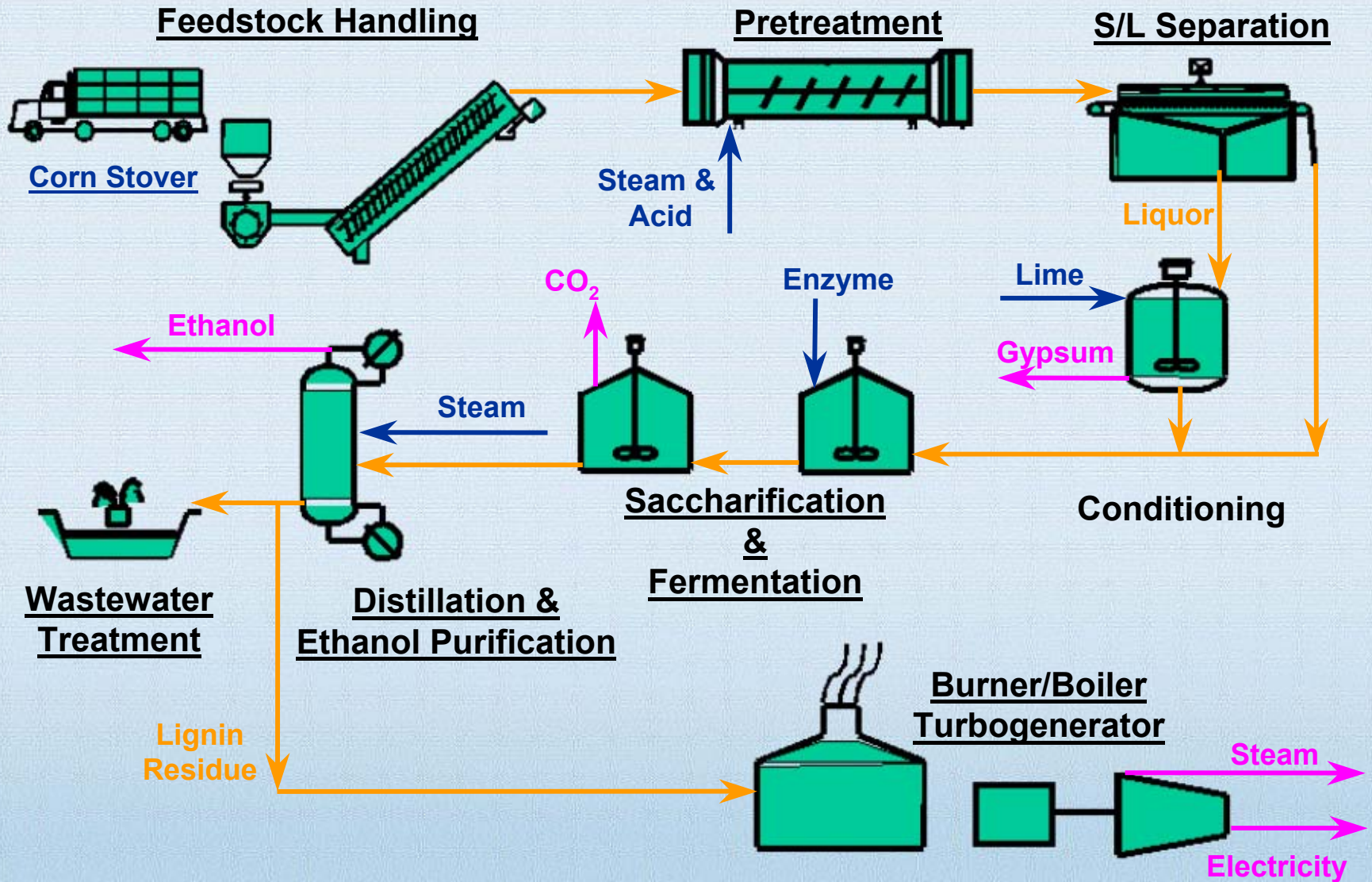
The Effect of Corn Stover Composition on Ethanol Process Economics

May 4, 2003

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- Understand the effect of feedstock composition on results from techno-economic assessments
- Begin to develop confidence intervals around results from techno-economic assessments



- In 2002, NREL published an updated target-case design report
 - Greenfield corn stover to ethanol process
 - NREL/TP-510-32438
 - www.nrel.gov/docs/fy02osti/32438.pdf
- Minimum Ethanol Selling Price (\$ per gallon ethanol) is the primary result



Design Case Economic Results

Plant Size: 2200 tons (2000 MT) Dry Corn Stover/Day (Greenfield Site)
Corn Stover Cost: \$30/dry ton

Economic Parameter (Units, \$2001)	Value
Minimum Ethanol Selling Price (\$/gal)	\$1.07
Ethanol Production (MM gal/yr)	69
Ethanol Yield (gal/dry ton stover)	90
Total Project Investment (\$ MM)	\$197
TPI per Annual Gallon (\$/gal)	\$2.86
Production Cost (\$/gal)	\$0.58



Design Case Stover Composition

Carbohydrates	% dry basis
Glucan	37.4%
Xylan	21.1%
Arabinan	2.9%
Galactan	2.0%
Mannan	1.6%
Total	65.0%

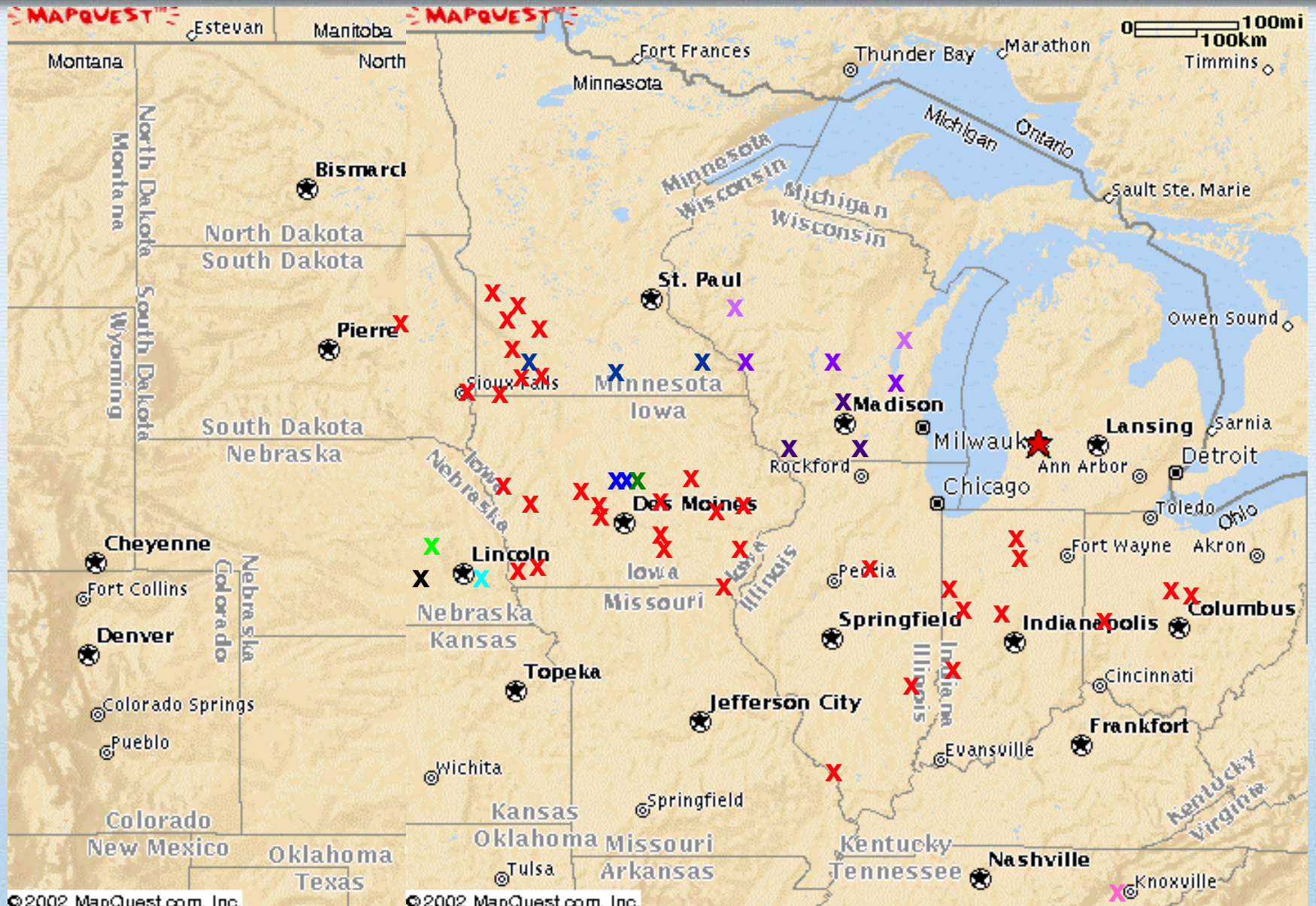
Other Components	% dry basis
Lignin	18.0%
Ash	5.2%
Acetate	2.9%
Protein	3.1%
Extractives	4.7%
Other	1.1%

- 112 hybrids
- 22 brands
- 52 sites in 10 states

- Asgrow
- Brown
- Dahlman
- Dairyland Stealth
- Dekalb
- Epley Brothers
- Garst/AgriPro
- Hoegemeyer
- Jung
- Kruger
- Midwest
- Mycogen
- NC+ Hybrids
- Northrup King
- Pioneer Hi-Bred
- Ramy
- Stauffer
- Viking
- Wilson
- Wyffels



Stover Collection Locations

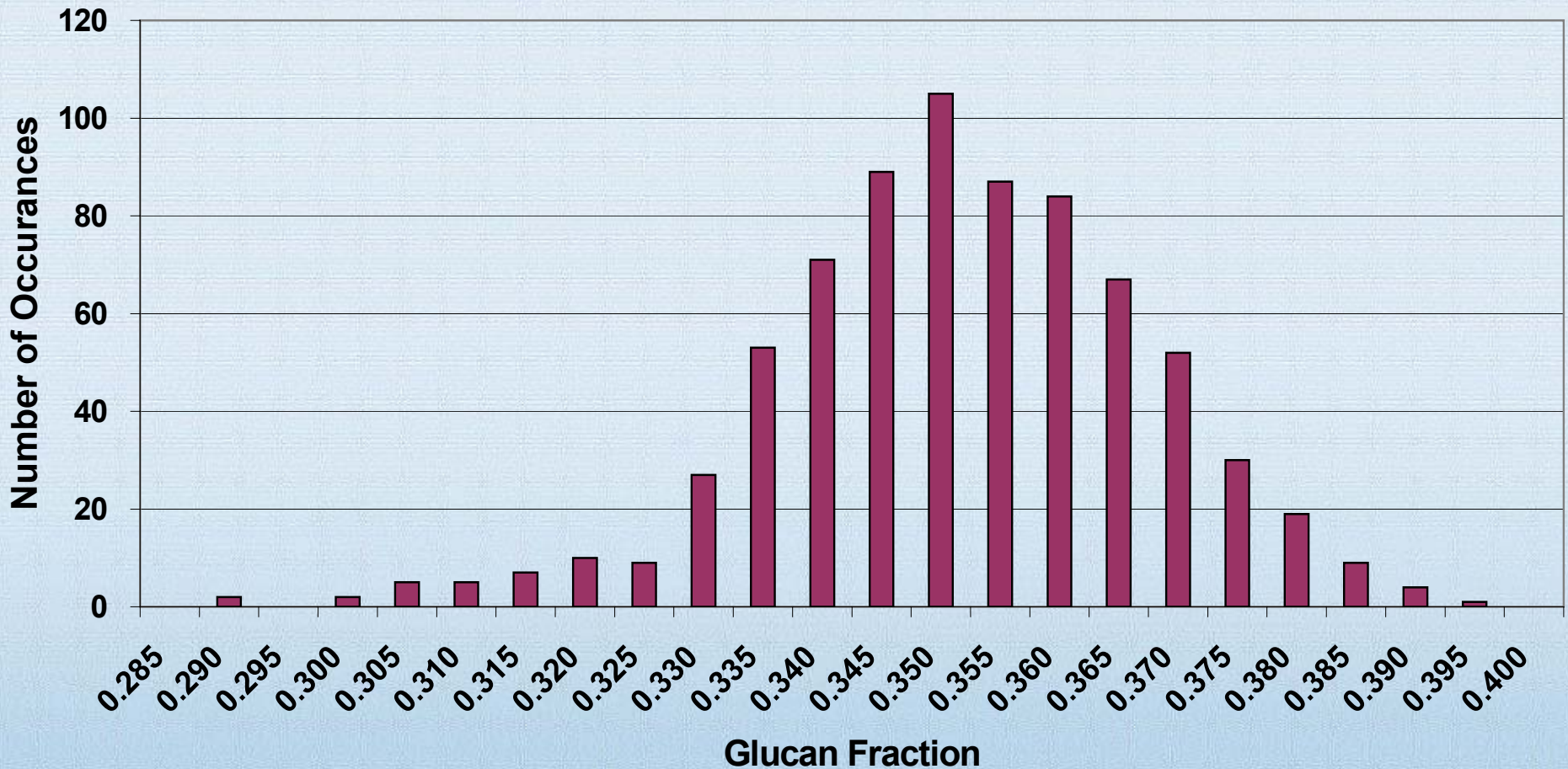




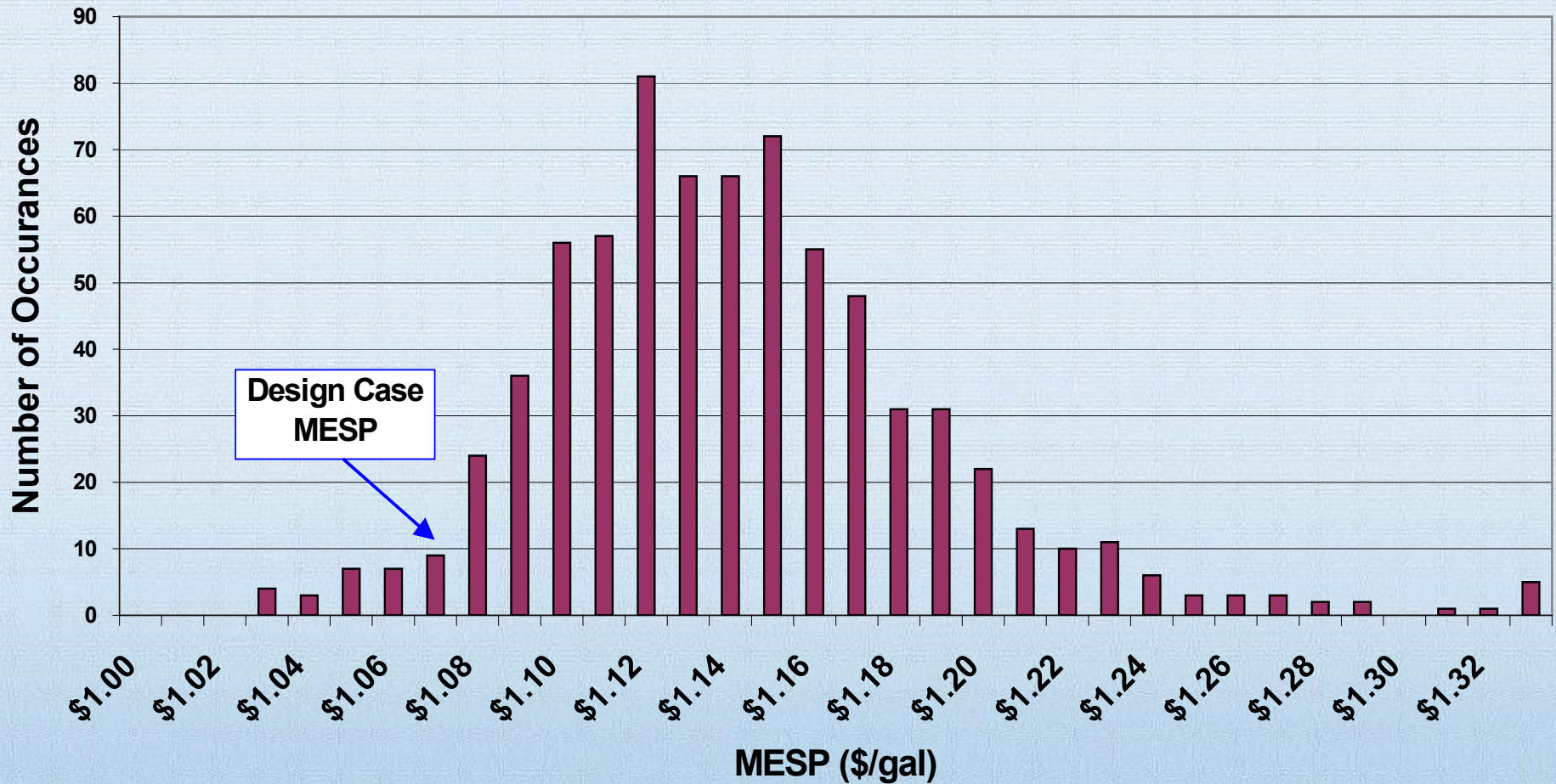
Composition Ranges

	Structural Glucan	Xylan	Lignin	Protein	Acetyl	Uronic Acids	Structural Inorganics (Silica, Ash)	Soil	Soluble Solids	Total
Minimum (% dry wt.)	27.9	14.5	11.5	1.3	0.9	1.4	-1.2	0.9	2.0	90.0
Maximum (% dry wt.)	39.6	25.5	20.4	7.0	3.9	3.9	10.2	1.7	19.6	101.9
Span (% dry wt.)	11.7	11.0	8.9	5.7	3.0	2.5	11.3	0.8	17.5	11.9
Mean (% dry wt.)	33.8	20.0	15.8	3.6	2.7	2.9	4.2	1.3	8.2	97.4
Standard Deviation (% dry wt.)	2.0	1.6	1.4	0.7	0.5	0.3	1.6	0.1	2.2	1.7

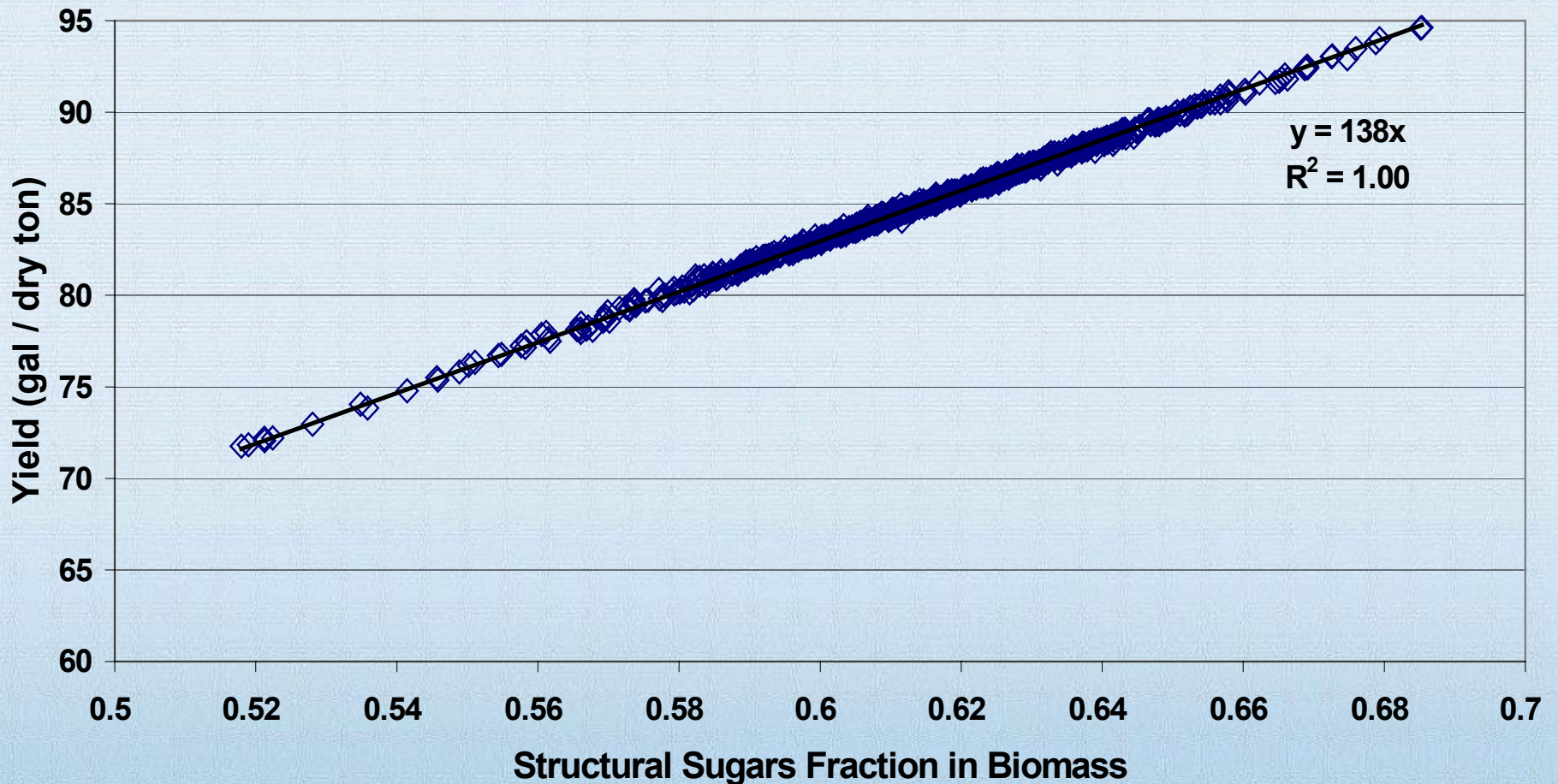
Normalized Structural Glucan Distribution



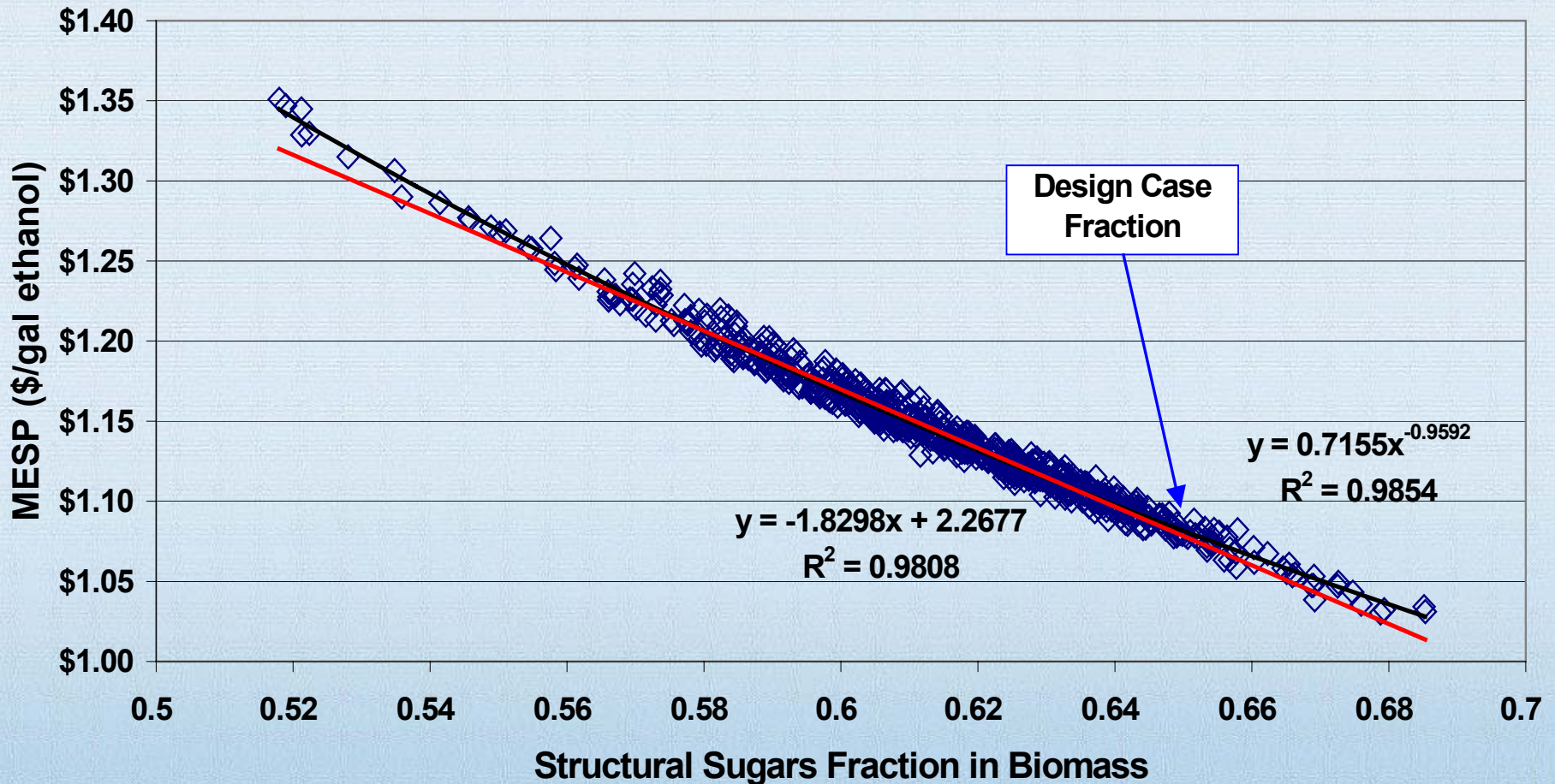
MESPs for 735 Stover Compositions



Structural Sugars' Effect on Yield



Structural Sugars' Effect on MESP



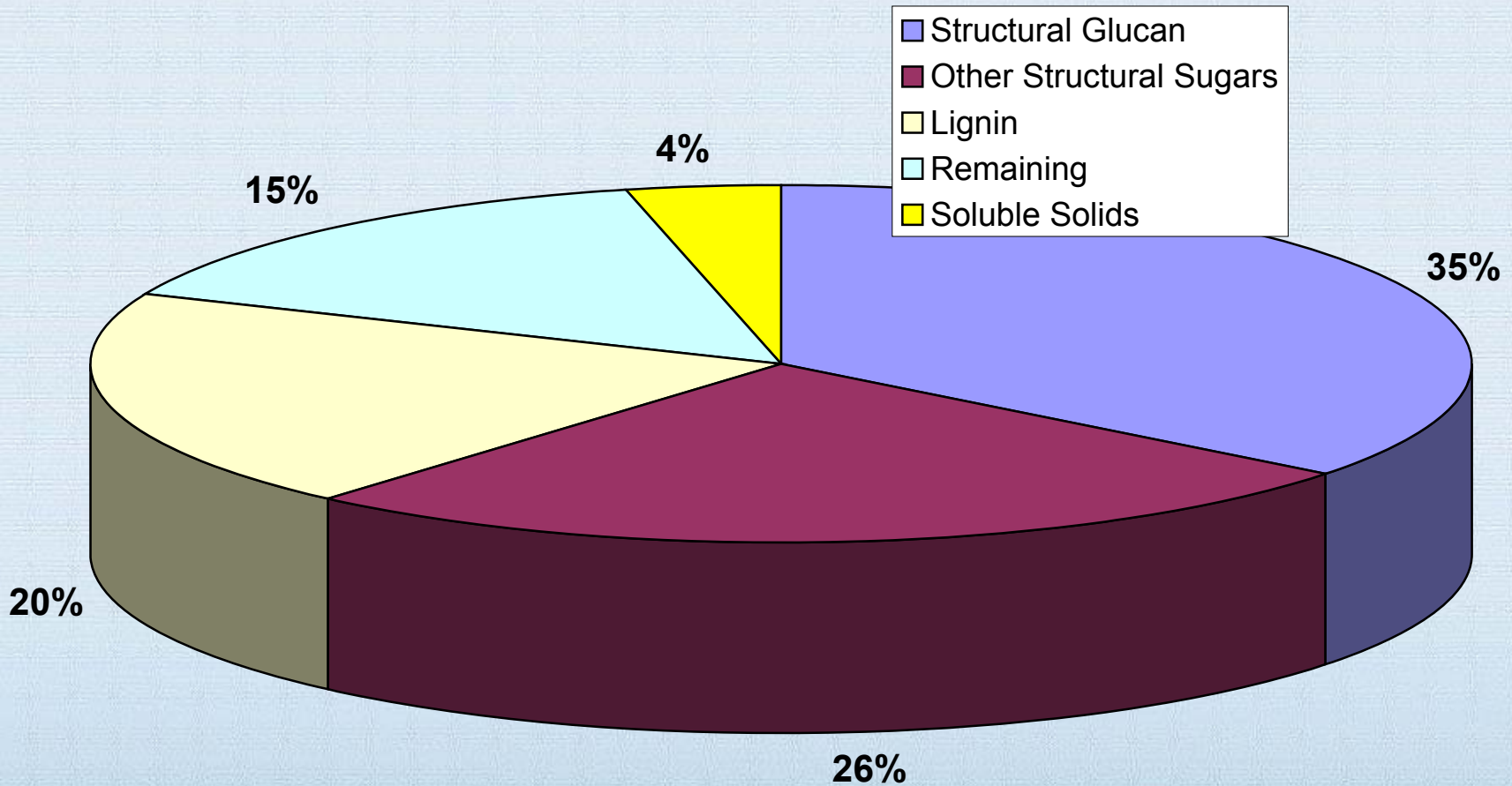
- Uses random numbers within defined functions to predict the uncertainty of modeled systems
 - Packaged software (e.g., Crystal Ball) makes it easier with Excel
- Used in the environmental, safety, business and other fields



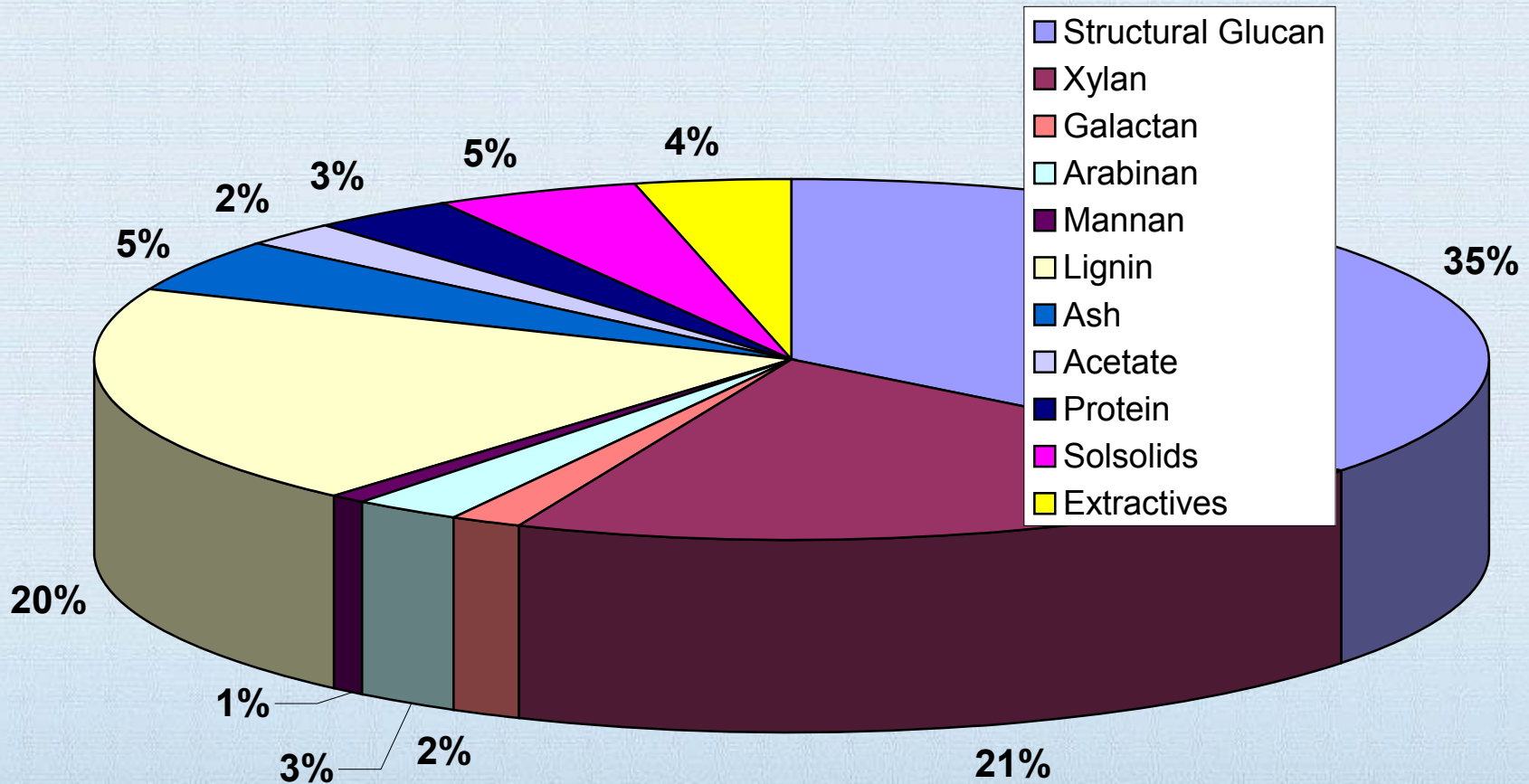
Feedstock Probability Functions

- Structural glucan
- Other structural sugars
- Xylan fraction of other structural sugars
- Lignin

- Constant ratios
 - Galactan/mannan/arabinan
 - Ash/acetate/protein/soluble solids

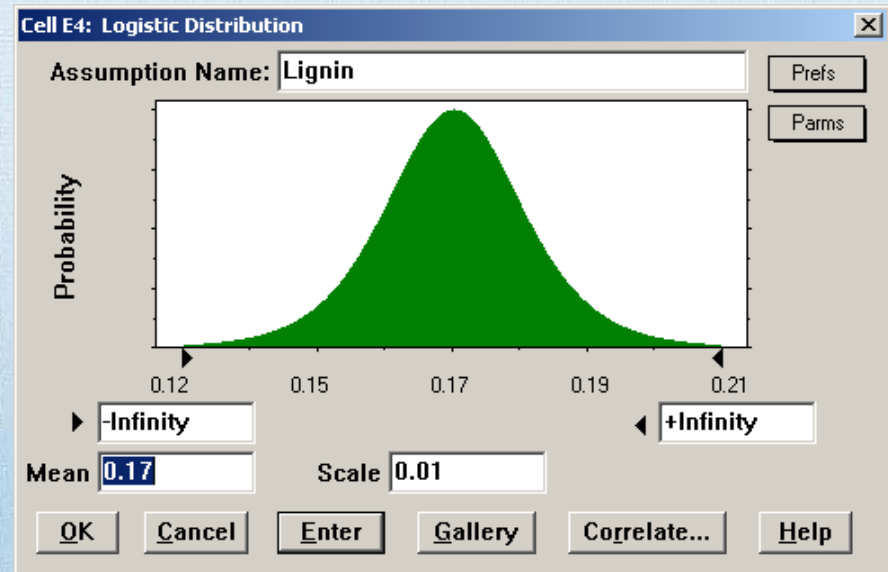
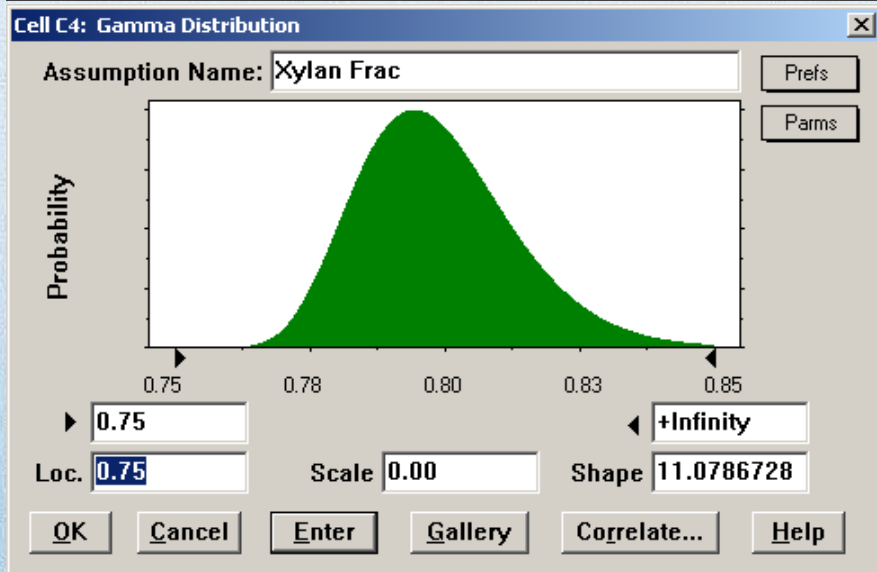
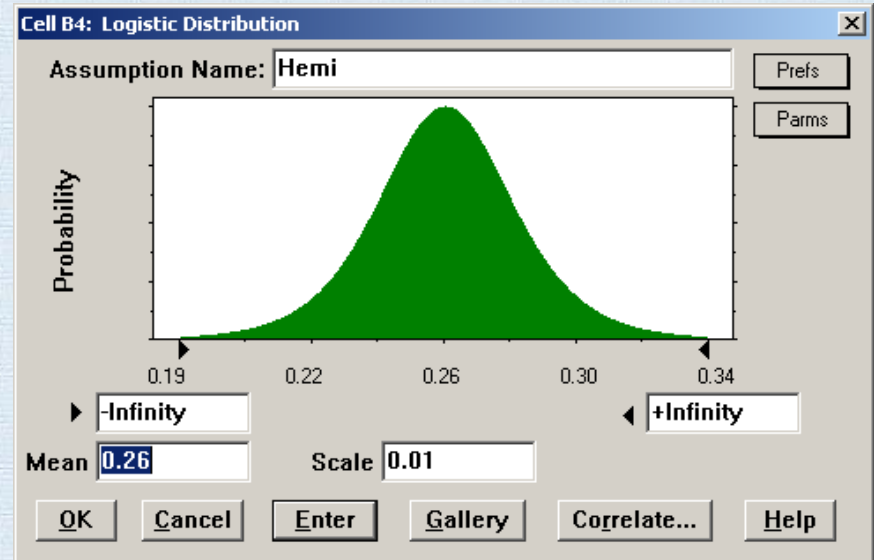
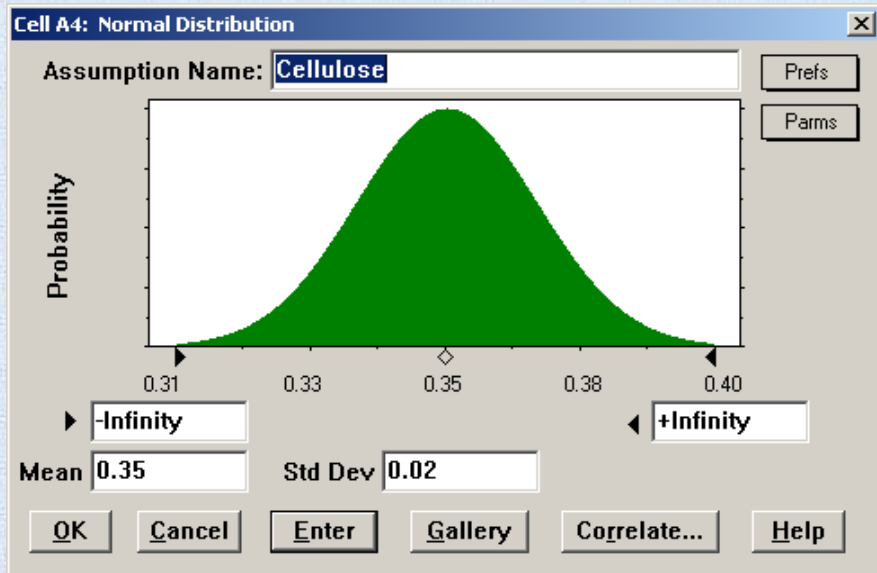


Component Breakdown



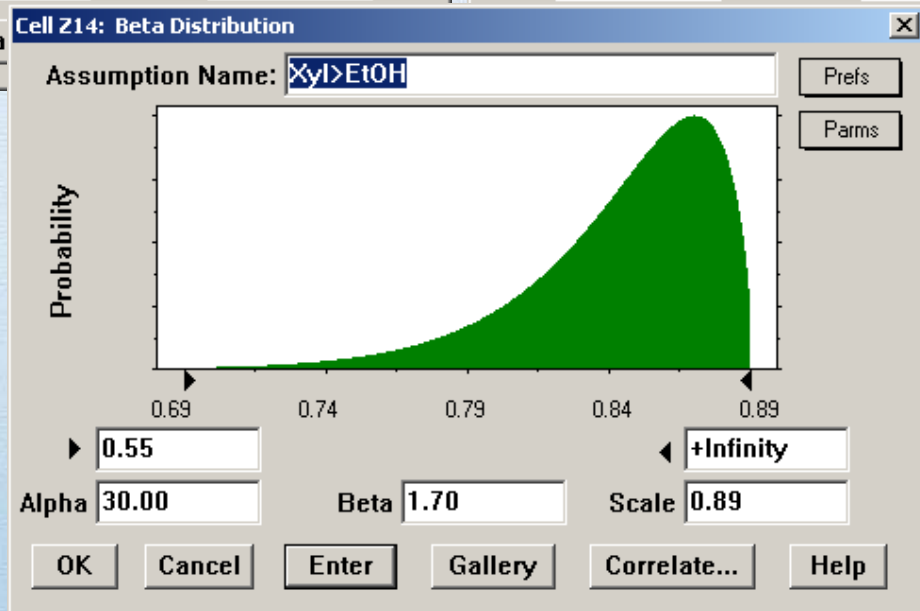
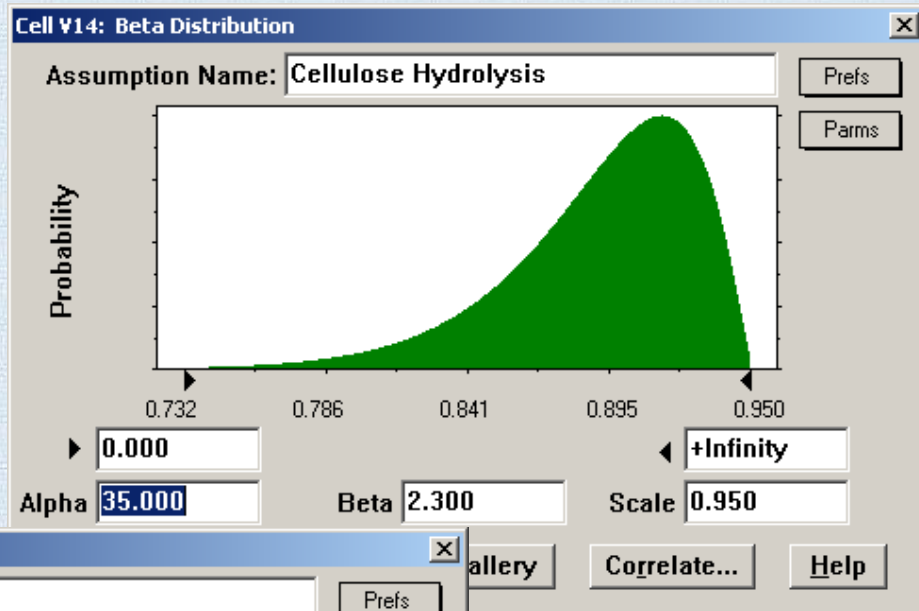
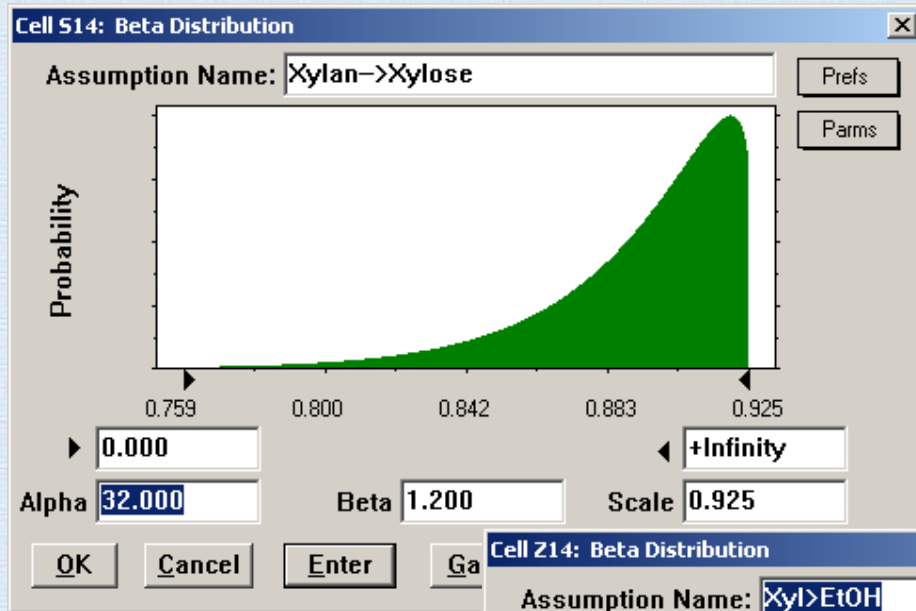


Feedstock Probability Distributions

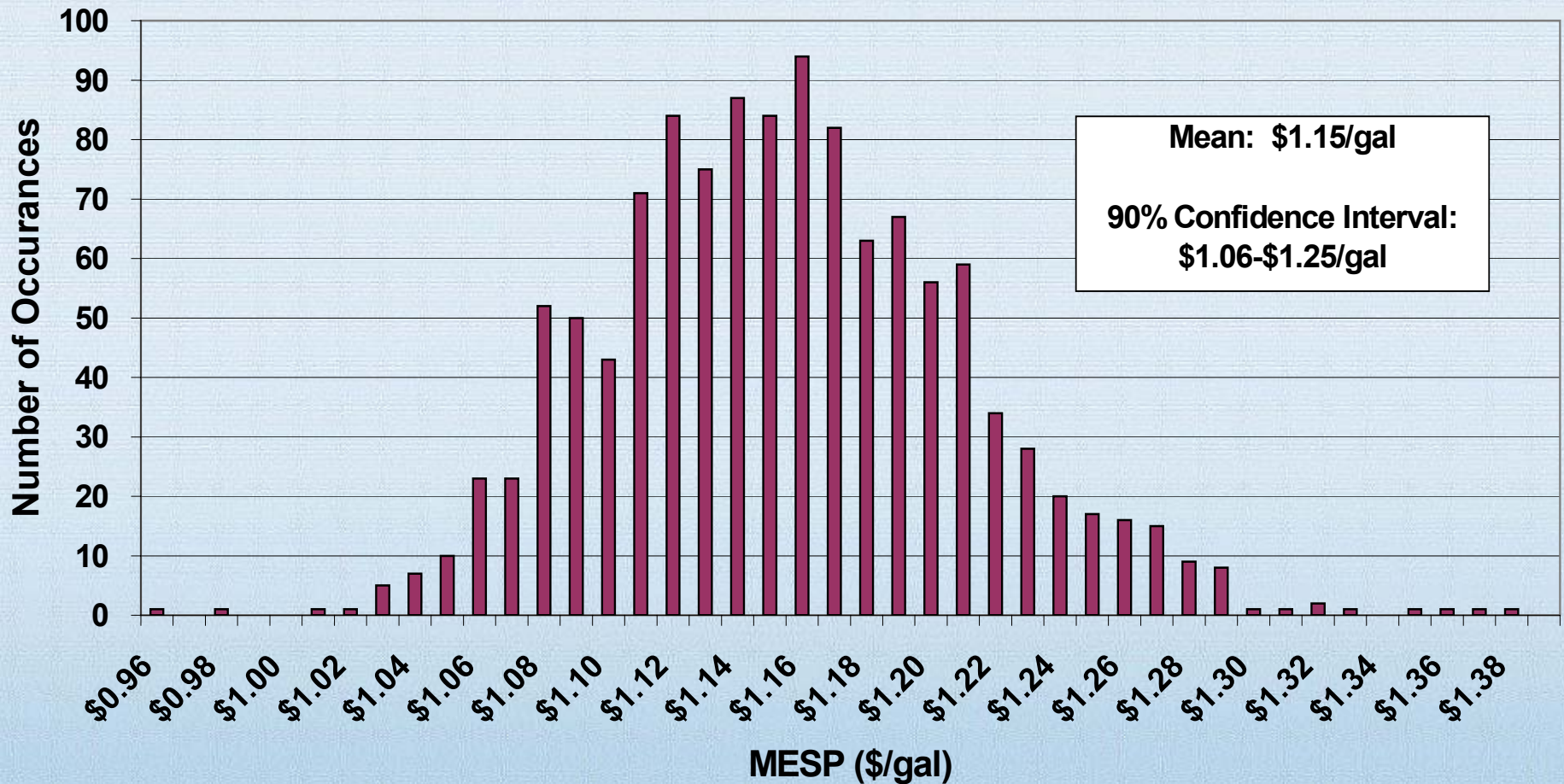




Yield Probability Distributions



Histogram of MESP for 1195 Monte Carlo Simulation Runs



- A carbohydrate change of 1% (of total dry matter) changes MESP by \$0.018/gal (within stover ranges)
- Monte Carlo is useful for confidence interval estimates
 - Reams of data improve function definition but estimates can be useful
 - This analysis gave an interval of \$1.06-\$1.25/gal



Acknowledgement

**This work supported by the Office of
the Biomass Program of the**

U.S. Department of Energy

**Office of Energy Efficiency and
Renewable Energy**

