Viability of Cellulosic Feedstock Production from Producer to Biorefinery

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Motivation/Backdrop

- General
  - -Environmental
  - -Energy independence
  - -Alternatives to grain based ethanol
  - -Renewable Fuels Standard (RFS)
    - *16 billion gallons of cellulosic ethanol by 2022
- Specific
  - -DOE grant recipients have expressed interest in the region
  - -Specific to sugarcane and sorghums
    - *Hybrid sorghum hay (HS hay)
    - *Hybrid sorghum greenchop (HS GC)
    - *Hybrid sorghum high biomass (HS HB)
    - *Sugarcane (cane)

Economic Problem

What is the cost and viability of obtaining cellulosic feedstocks in the Upper Coast region of Texas, and what is the potential on-farm financial impact of dedicating acreage to energy feedstock production in that region?

Research Objectives

1) Estimate the most cost effective and agronomically feasible dedicated energy crop mix for cellulosic ethanol production in Southeast Texas.

2) Estimate the contract price per ton needed for farmers to grow cellulosic feedstock and forgo their next best alternative in Southeast Texas.

3) Determine the financial impact on the whole farm of switching from its current crop mix to one consisting of dedicated energy crops.

4) Estimate the cost per ton to harvest and transport alternative cellulosic crops to a bio-refinery located in Southeast Texas.

Overview of Previous Research

- Approximately three decades of research largely dedicated to switchgrass
  - -Oak Ridge National Laboratory (ORNL)
  - -National Renewable Energy Laboratory (NREL)
  - -The University of Tennessee
  - -Iowa State University
  - -Oklahoma State University
  - -The University of Nebraska
- Hybrid sorghums and sugarcane
  - -Texas A&M University
  - -The University of Florida
  - -Louisiana State University
- Many others both domestically and internationally

Methods – Module 1

- Partial Budget Analysis
  - -Identification of alternative enterprises
  - -Estimation of revenues and costs

- Monte Carlo Simulation
  - -Identification of stochastic variables
    - *Yields, input prices, and output prices for non-energy crops
  - -Multivariate GRKS and nonparametric distributions

- Hauling distance algorithm to account for bio-density and square road system

- Key Output Variables
  - -Most cost effective energy crop mix
  - -Contract prices to grow ($/dry ton)
  - -Net returns per acre ($/acre)
  - -Growing cost to biorefinery ($/dry ton)
  - -Harvest and hauling costs ($/dry ton)
  - -Total Cost to biorefinery ($/dry ton)

•Stochastic Efficiency with Respect to a Function (SERF) Analysis

Methods Module 2

- Whole-farm simulation model (*FARM Assistance*)
  - -Uses energy crop mix & contract prices from module 1
  - -Typical non-energy crop mix
  - -Government payments
  - -Full accounting matrix
  - -Compares a base scenario to two alternative energy crop scenarios
    - *Hybrid sorghum
    - *Sugarcane

- Key Output Variables
  - -Net cash farm income (NCFI)
  - -Ending cash reserves & probability of refinancing
  - -Real net worth (RNW)
  - -7 other metrics

Data

- Current Alternative Enterprises (yields, price wedges, costs)
  - -Panel of area producers
  - -*FARM Assistance* database
- Energy Crops (yields, costs, percent dry matter, harvest periods)
  - -University agronomists & ethanol industry representatives
- Baseline Estimates Through 2017 (inflation, national prices)
  - -Food and Agricultural Policy Research Institute (FAPRI)
- Historical Data to Model Variability (inflation, national prices)
  - -Food and Agricultural Policy Research Institute (FAPRI)
- Baseline Harvest & Hauling Costs
  - -NASS Custom Rates Statistics
- Ethanol Production Assumptions (gallons of output, conversion rates)
  - -Ethanol industry representatives
  - -Previous studies

Assumptions (Abbreviated)

- Agricultural producers are contracted to grow only
  - -Two-stage contract (fixed per acre payment & a price per unit of production)
- Percent farmland in vicinity of biorefinery (90%)
- Percent of farmland converted to energy crops (30%)
- Chance of destructive weather (10%)
- Annual biorefinery output (25 million gallons)
- Gallons of ethanol per dry ton (90)
- Percent dry matter
  - -Hybrid sorghum hay (85%)
  - -Hybrid sorghum greenchop (30%)
  - -Hybrid sorghum high biomass (40%)
  - -Hybrid sugarcane (34%)
- Average crop yields under normal weather conditions (wet weight)
  - -Rice (75 cwt)
  - -Pasture hay (9 ton)
  - -Hybrid sorghum hay (17.65 ton)
  - -Hybrid sorghum greenchop (50 ton)
  - -Hybrid sorghum high biomass (37.5 ton)
  - -Hybrid sugarcane (45 ton)

Results

Most Cost Effective & Agronomically Feasible Energy Crop Mix

- Hybrid Sorghum Green Chop (HS GC) — 2 months
- Hybrid Sorghum Hay (HS Hay) — 2 months
- Hybrid Sorghum High Biomass (HS HB) — 2 months
- Sugarcane (cane) — 6 months

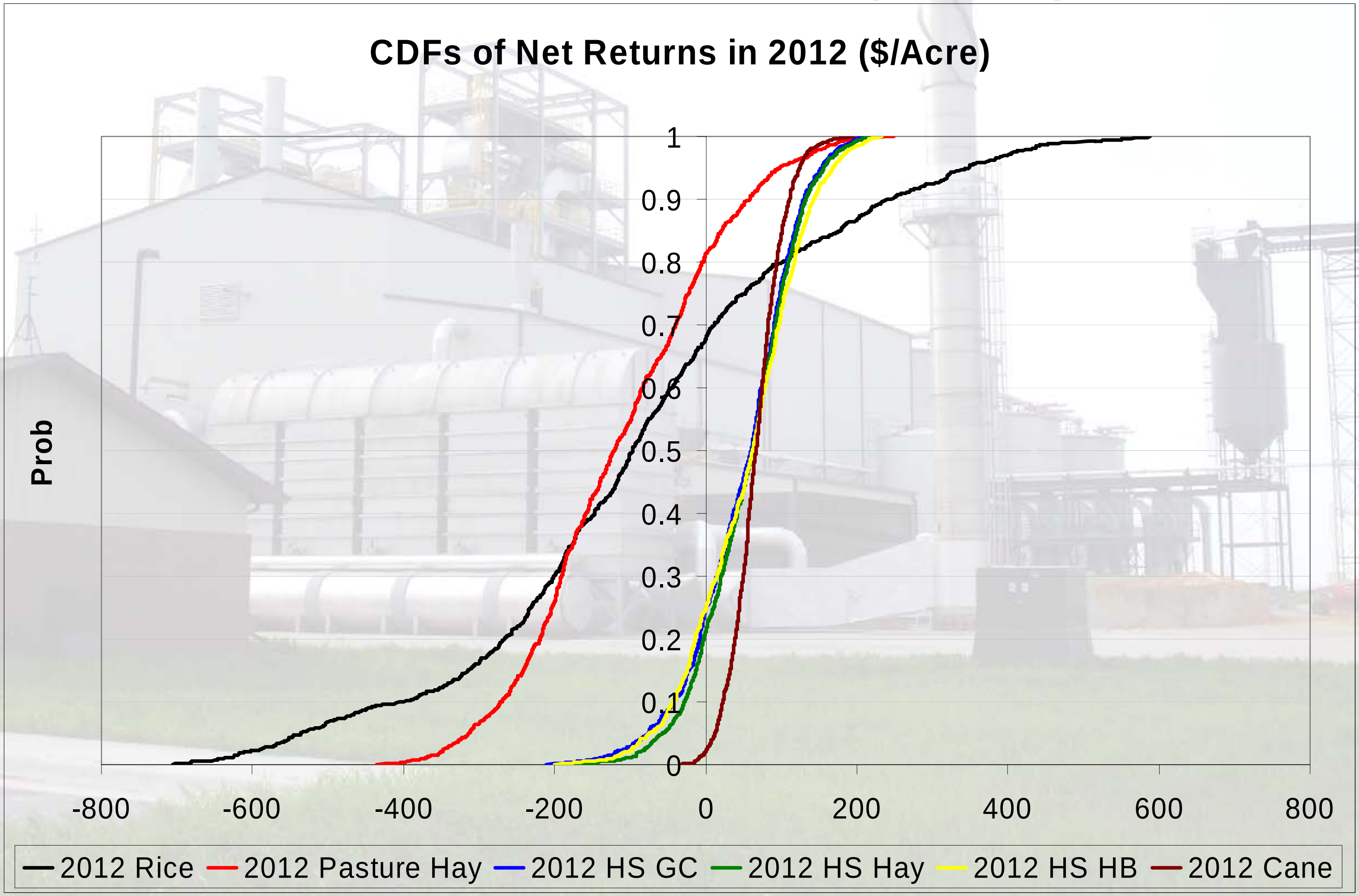
Results

Estimated Contract Prices to Grow Energy Crops (2008-2017), $/ton Dry Matter

Year	HS Hay	HS GC	HS HB	Cane
2008	36.23	36.24	38.45	27.51
2009	37.34	37.34	39.75	28.19
2010	37.75	37.75	40.21	28.59
2011	37.79	37.80	40.22	28.91
2012	37.82	37.83	40.24	29.18
2013	38.02	38.03	40.41	29.53
2014	38.52	38.53	40.93	30.04
2015	39.13	39.13	41.56	30.60
2016	39.66	39.66	42.12	31.07
2017	40.26	40.26	42.76	31.59

Results

Estimated Returns to Growers (2008-2017)



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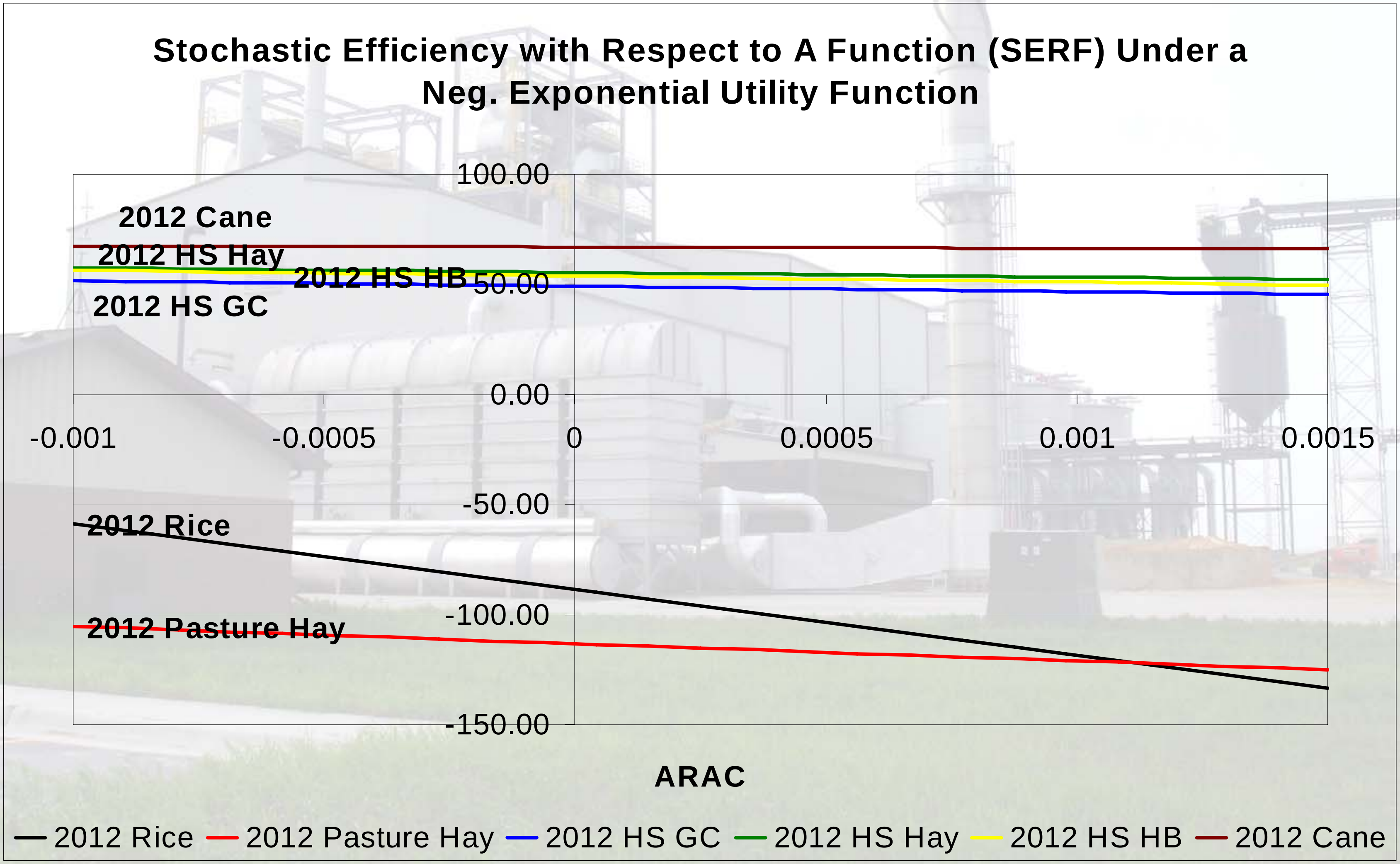
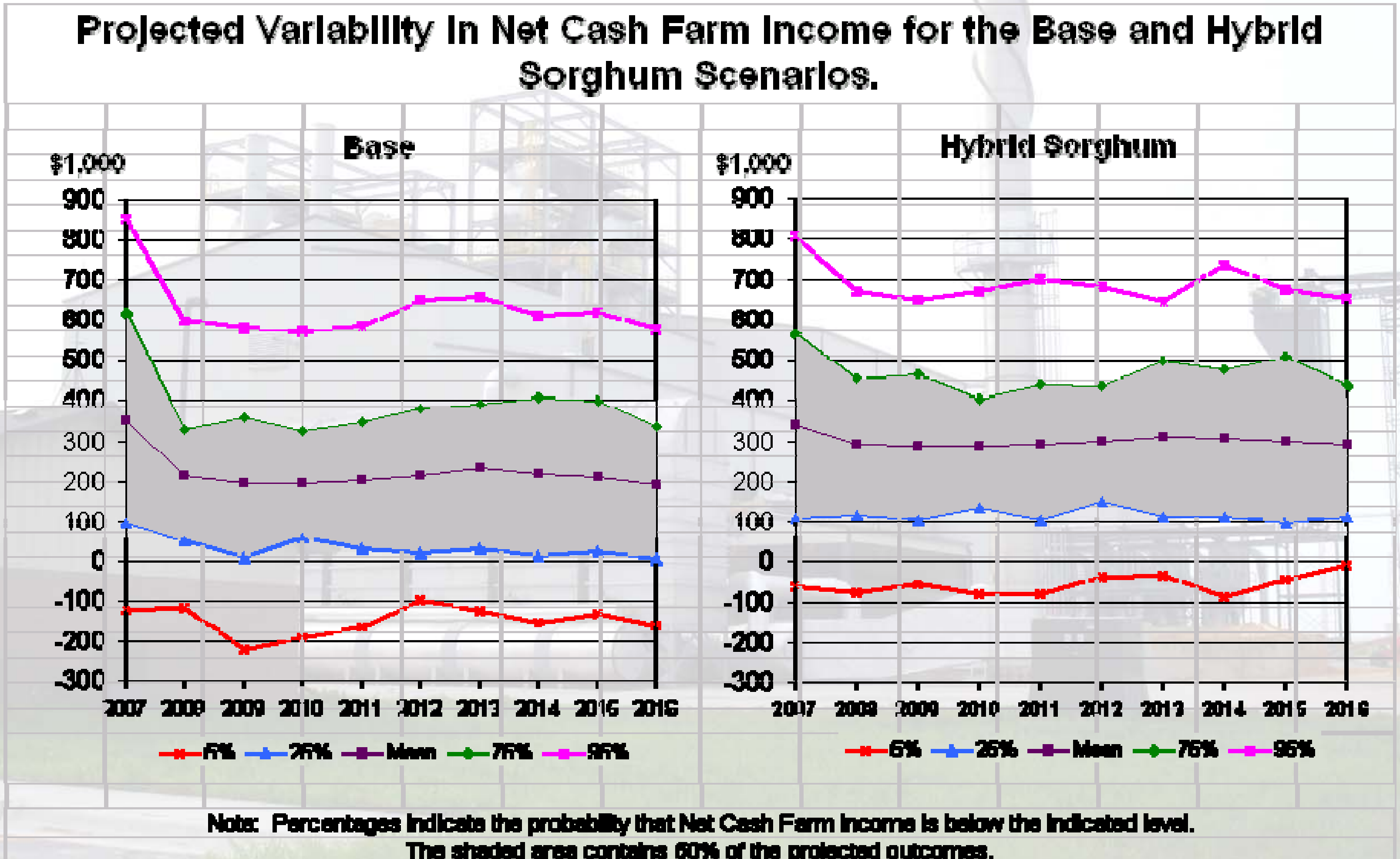


Results

Whole-Farm Financial Implications (2007-2016)



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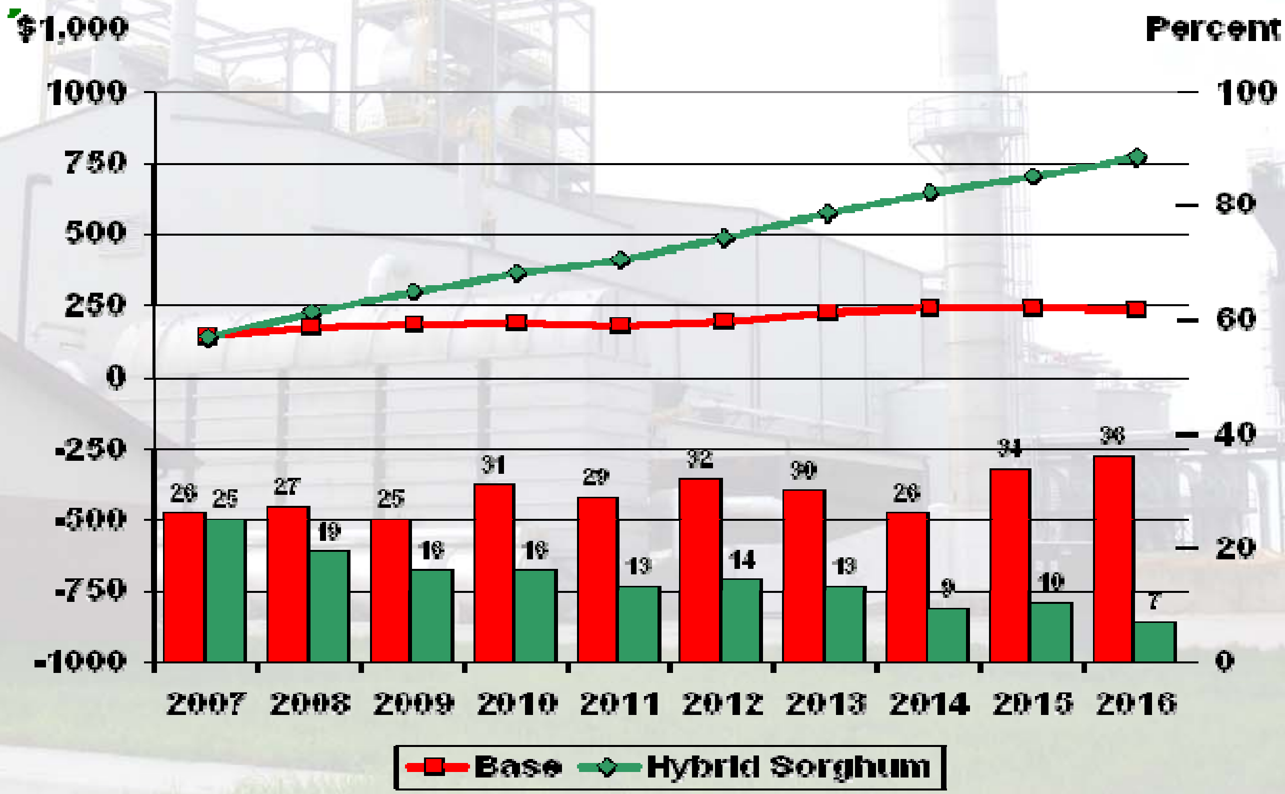
Results

Whole-Farm Financial Implications (2007-2016)

Ending Cash Reserves and Probability of Having to Refinance Operating Note for the Base and Hybrid Sorghum Scenarios.



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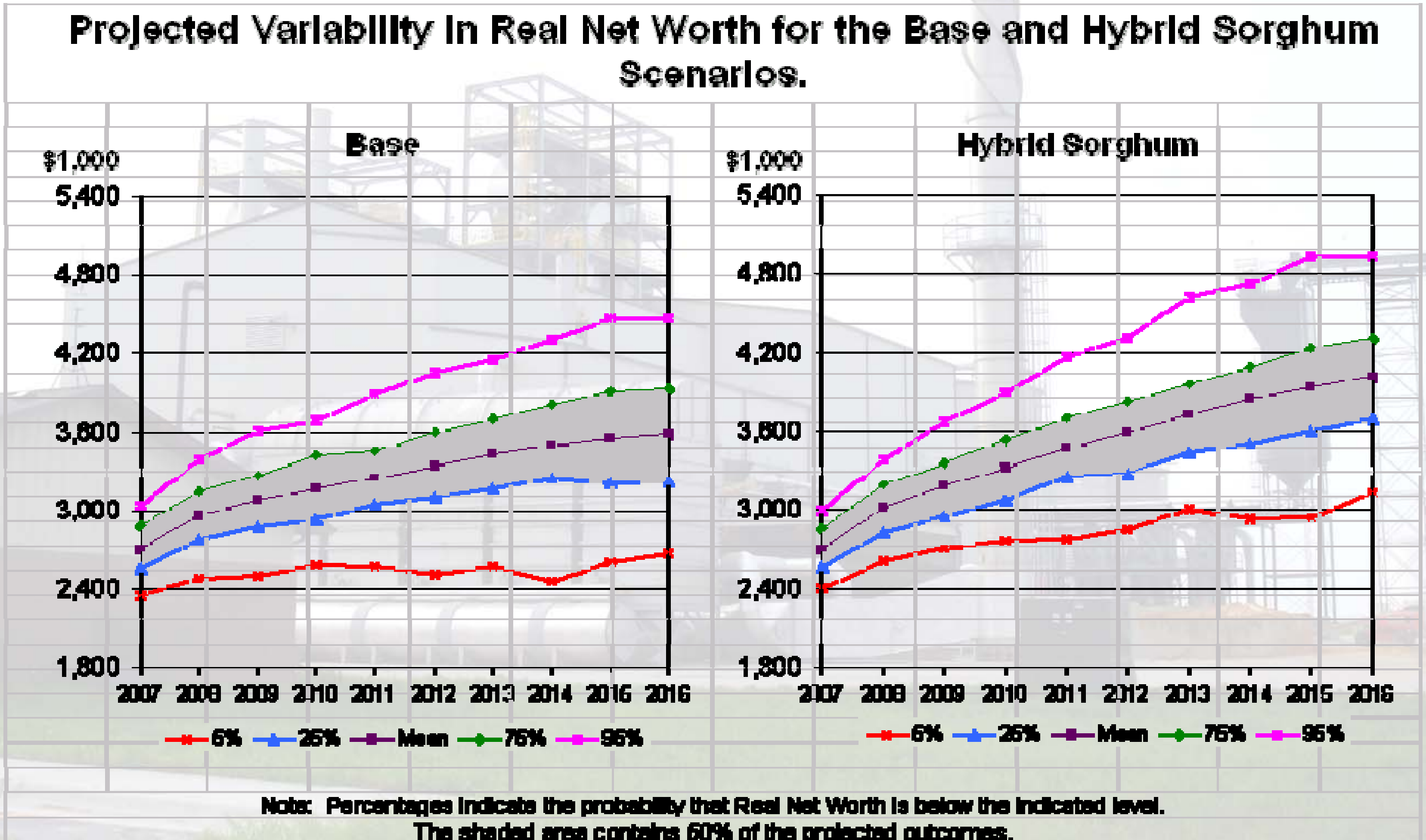

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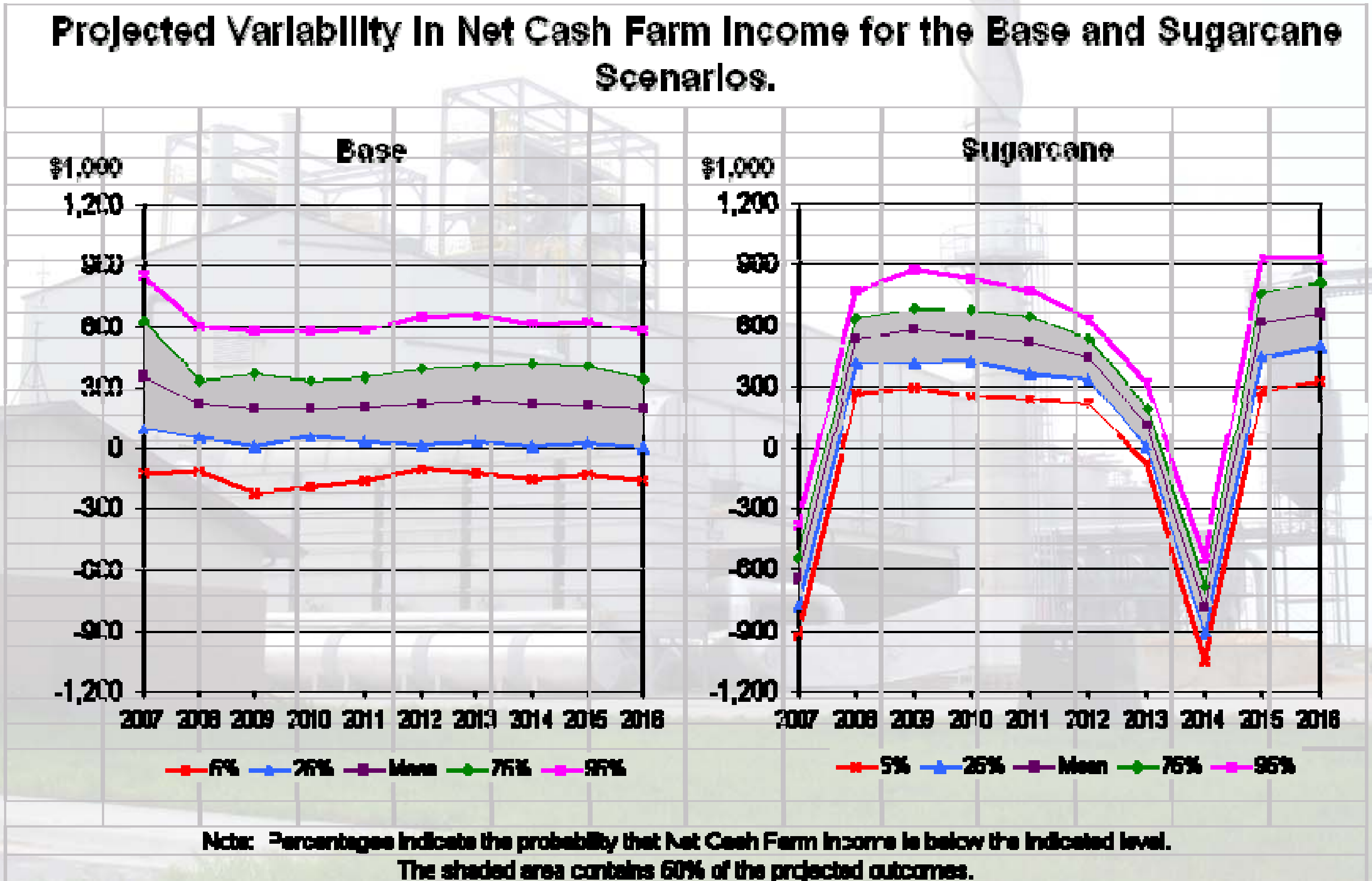

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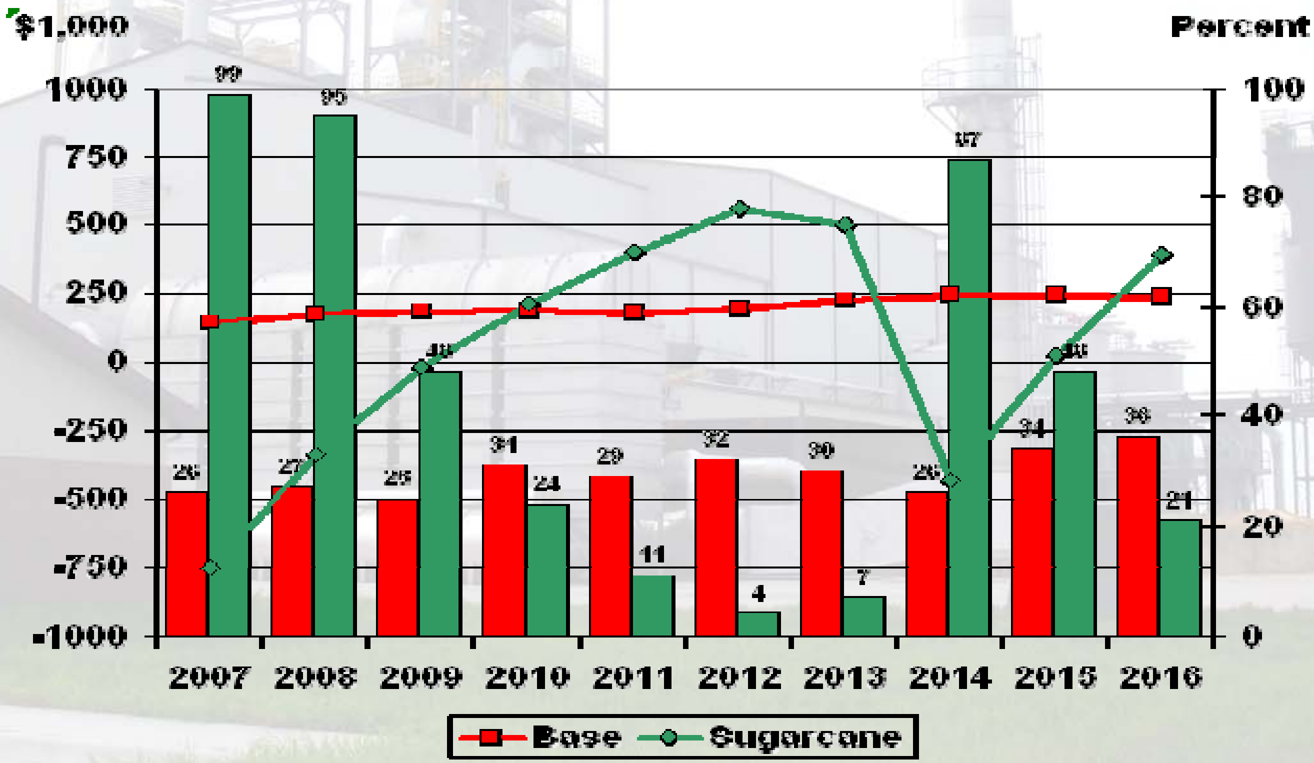

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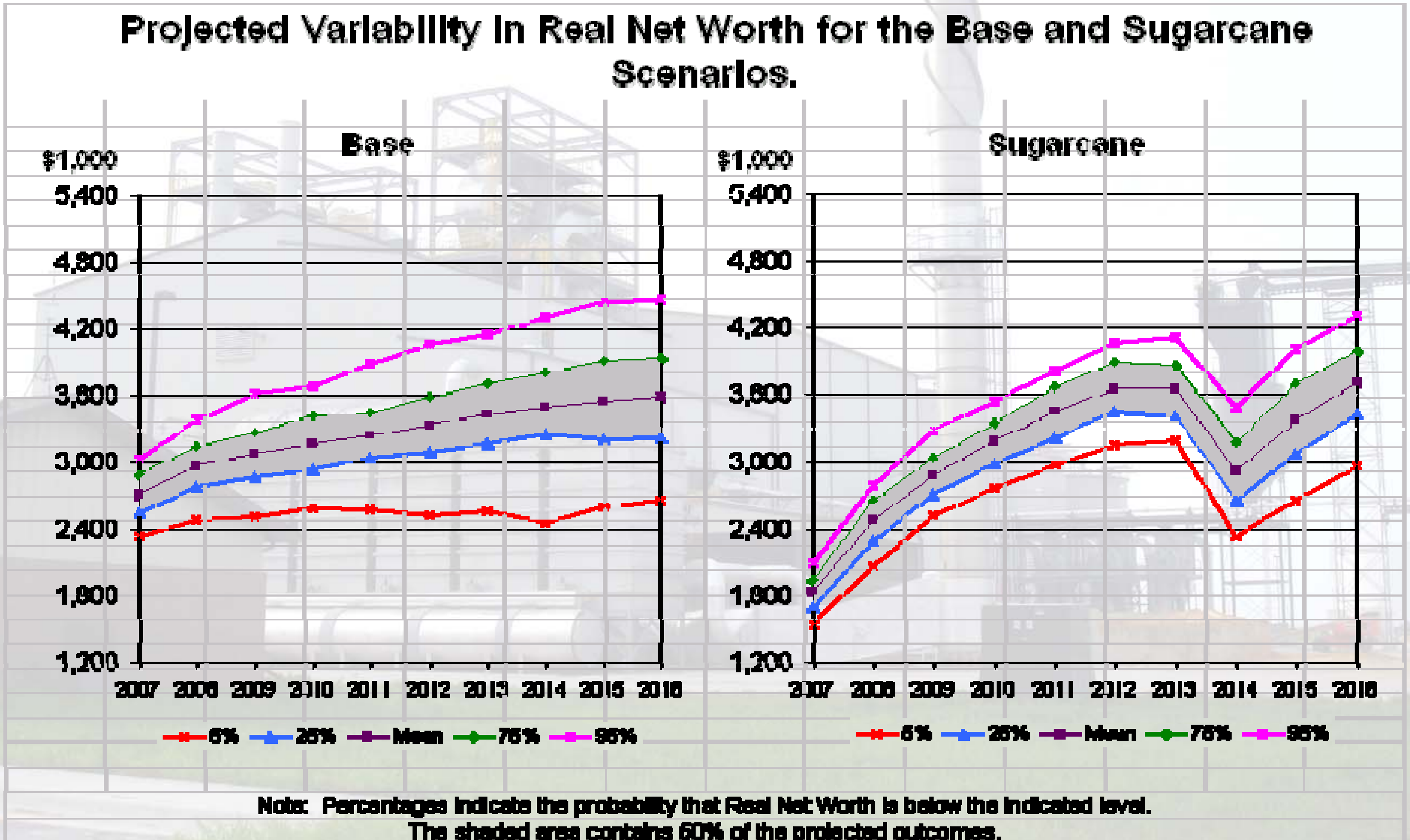

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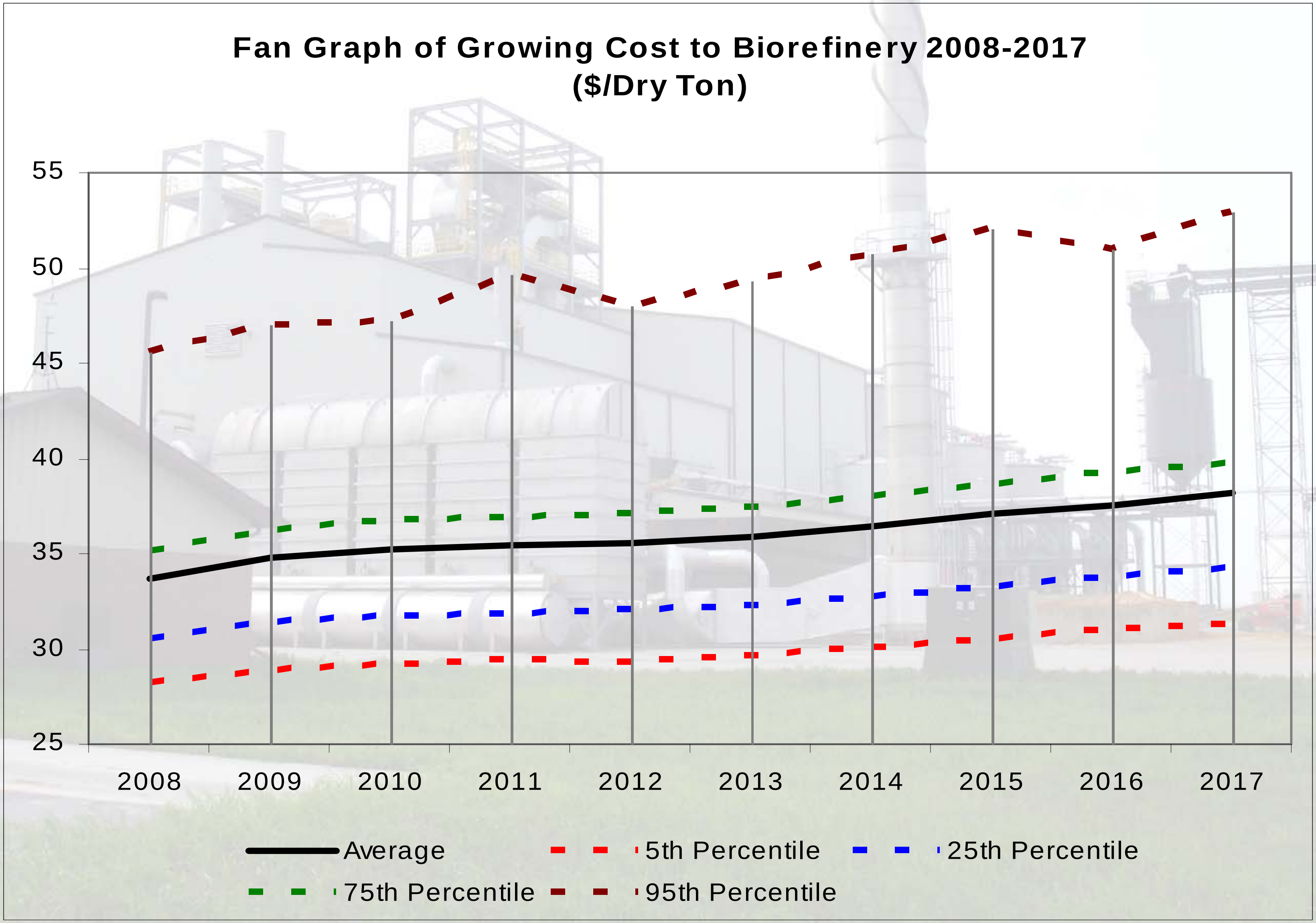
Delivered Cost to Biorefinery (2008-2017)



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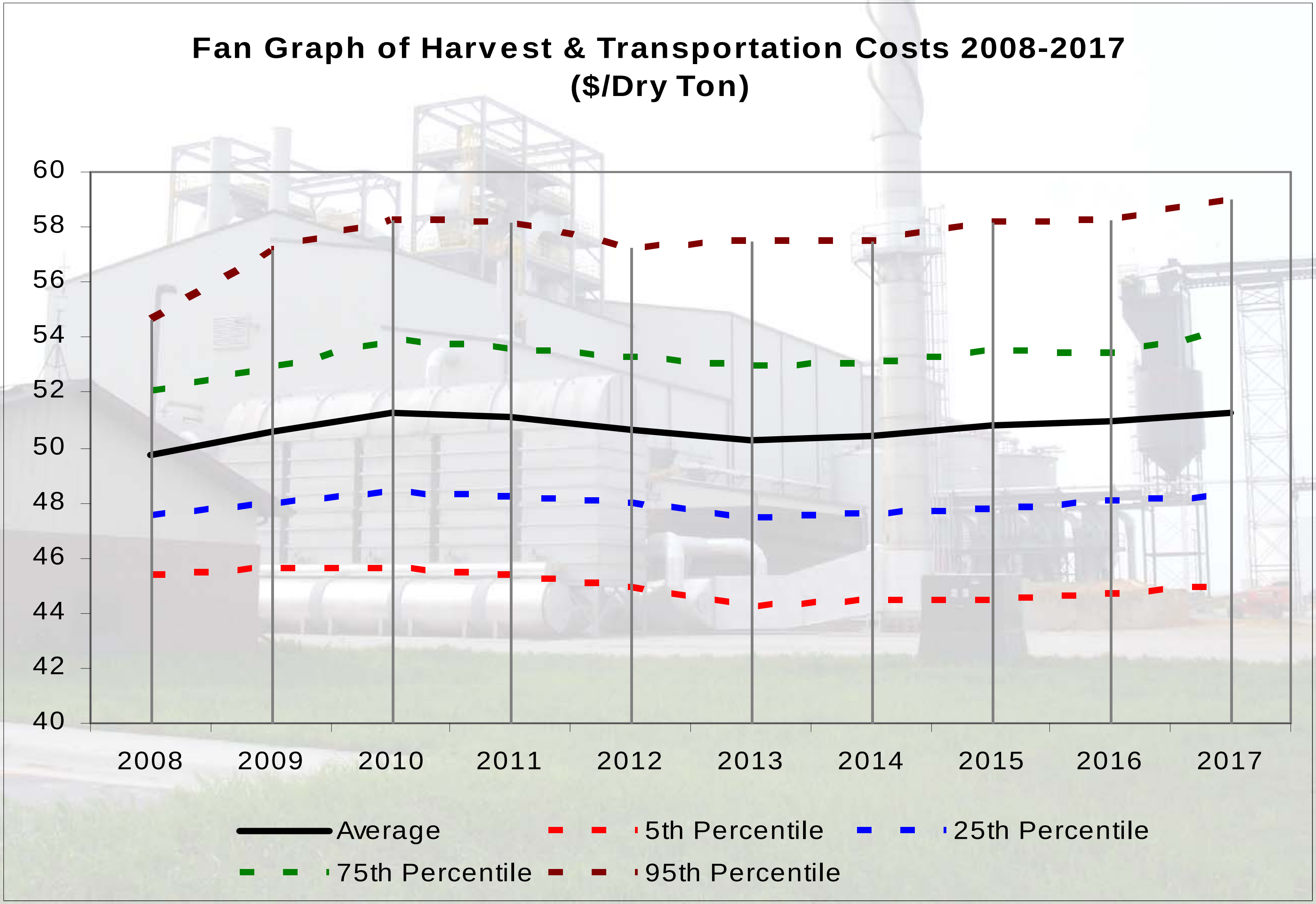

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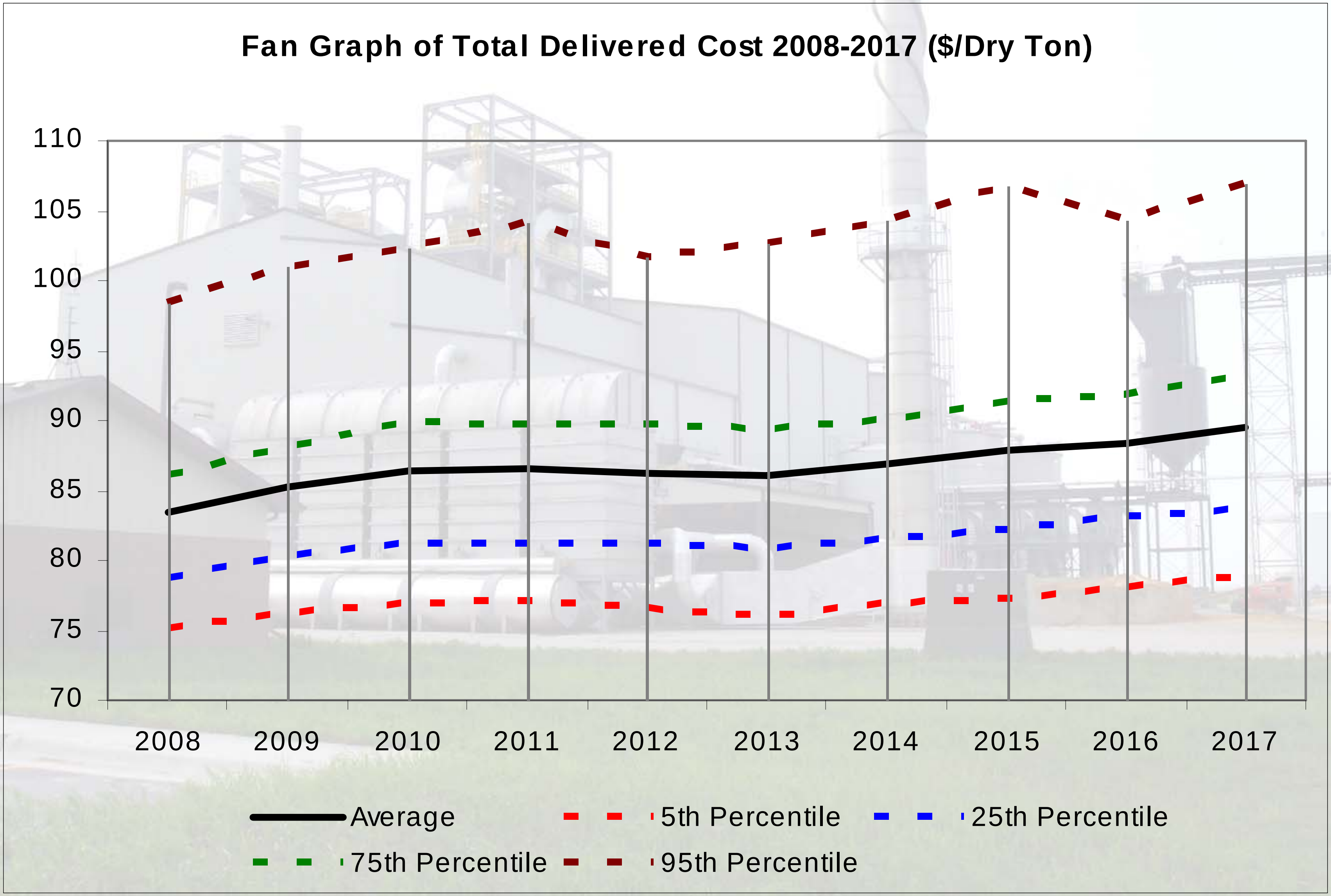

Results Summary

- Dedicated energy crops are an economically feasible option for producers in the region, if proposed contract prices can be met by the biorefinery.

- Based on the assumptions, cellulosic feedstock can be delivered in the region at an average cost of approximately $87 per dry ton.

Implications

- Results are generally consistent with the findings of Epplin et al in 2007:

Considerable advancements must be made to meet the National Renewable Energy Laboratory (NREL) goal of $35 per dry ton of delivered feedstock.

Limitations & Opportunities for Future Research

1. The analysis does not account for potential sources of additional feedstock when yields are low on contracted acreage.

2. The analysis does not account for potential secondary markets for excess feedstock when yields are high.

3. What is the optimal contract structure, and how many acres should actually be contracted to optimize profitability of the biorefinery?

Questions/Comments