# Biomass: Producer Choices, Production Costs and Potential

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Transition to a Bioeconomy:
The Role of Extension in Energy
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# Renewable Fuel Standards – RFS 2

Energy Independence and Security Act of 2007

36 billion gallons of biofuel by 2022

15 B gal conventional (“Corn Ethanol”)

21 B gal of 2nd generation biofuel

- **16 B gal of cellulosic (primarily cellulosic ethanol)**
  - 4 B gal of advanced biofuel
  - 1 B gal of biomass based diesel

# RFS – 2
## US EPA estimates of feedstock sources to meet 16 B gal mandate (2022)

- 9.0 B - crop residues
  - 7.8 B - corn stover
- 3.9 B - forestry biomass
- 2.1 B - urban waste
- 0.9 B - switchgrass or other dedicated energy crops

# US EPA Projections (Goals) For 2022 (In 2006 Dollars)

- Gasoline @ $2.05 / gal

    Ethanol has 2/3 energy content of Gasoline

- Breakeven Ethanol Price @ $1.35 / gal

- US EPA estimates cellulosic ethanol can be produced for $1.31 / gal

# US EPA Projections (Goals) For 2022 (In 2006 Dollars)

Assumptions

- A flow of feedstock can be delivered throughout the year for **$73 / dry ton**
- Biomass can be converted at a rate of

  **94 gal / ton**
- Cellulosic Ethanol Goal - $1.31 / gal
  - **$0.78** for feedstock
  - **$0.53** for conversion

- Breakeven Ethanol Price with $2.05 gasoline is $1.35 / gal

# DOE NREL 2012 Goal vs. EPA 2022 Goals

DOE NREL (2012 goals)

- Delivered feedstock cost of **$35/dry ton**

- 90 gal/t
- $0.39 /gal – feedstock
- $0.68/gal – conversion

- Cellulosic Ethanol for $1.07/gal

Source: Pacheco 2006

EPA (2022 goals)

- Delivered feedstock cost of **$73/dry ton**

- 94 gal/t
- $0.78 /gal – feedstock
- $0.53/gal – conversion

- Cellulosic Ethanol for $1.31/gal

Source: US EPA 2009

The Role of Extension in Energy

Transition to a Bio Economy

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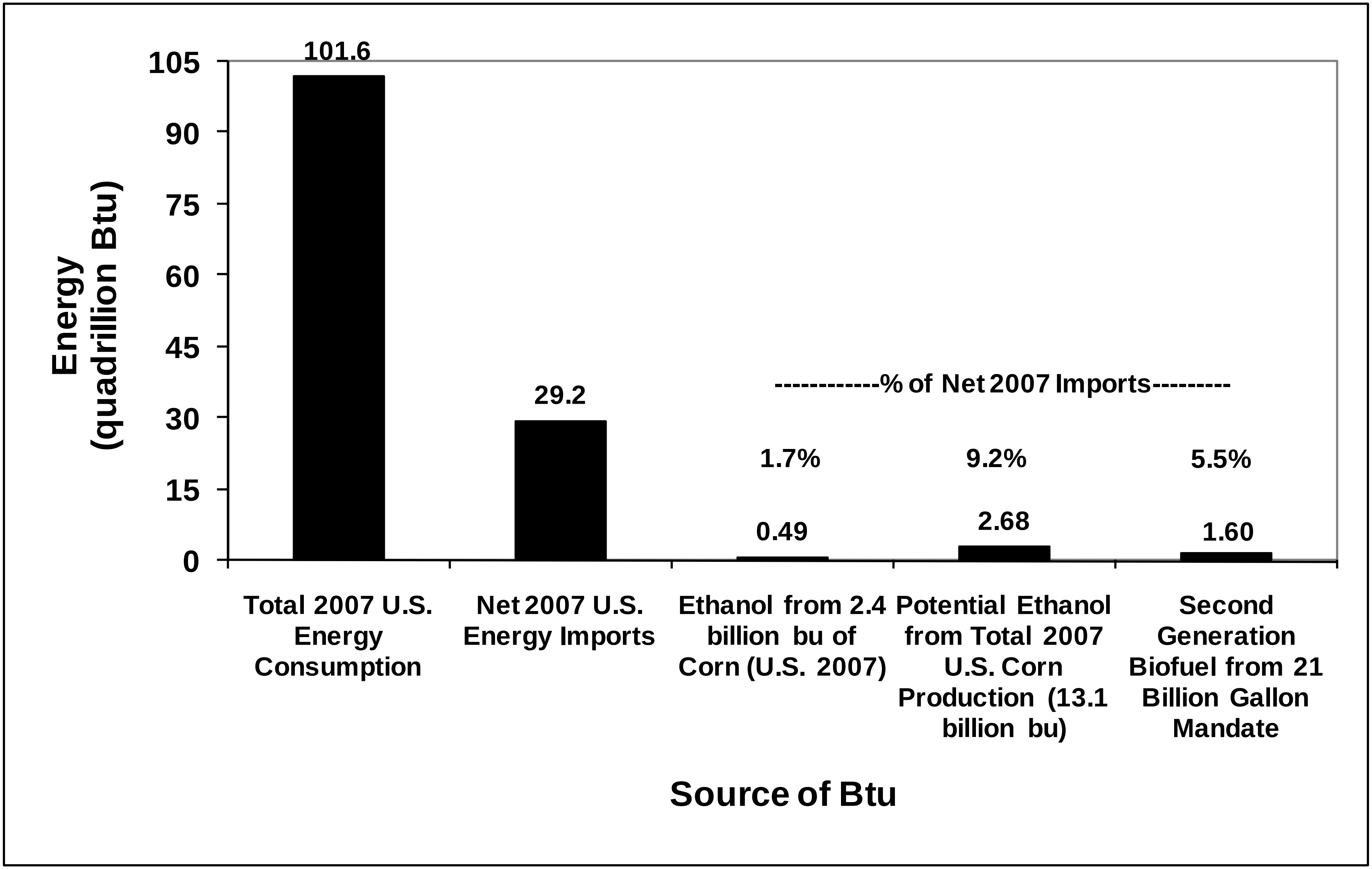
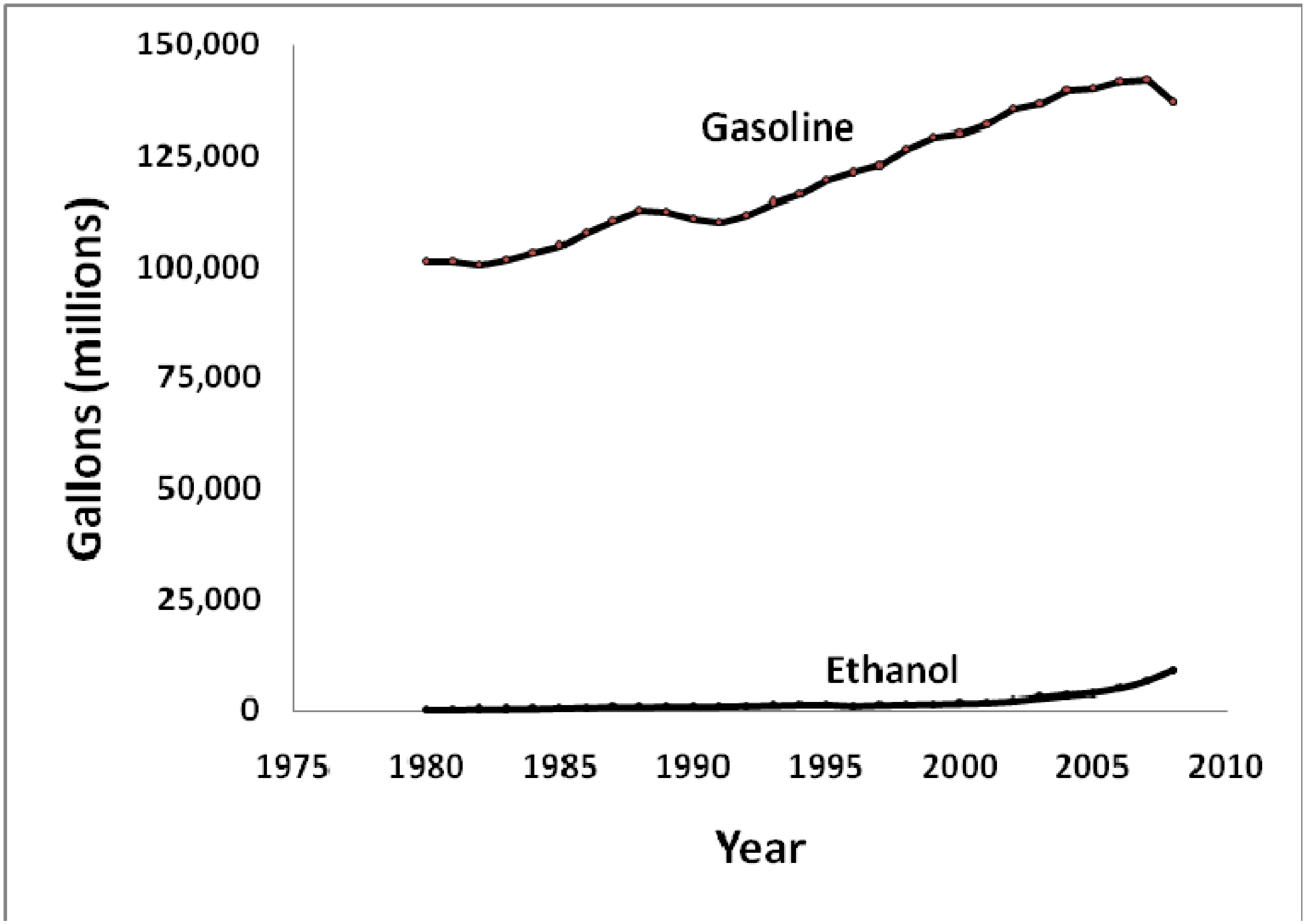
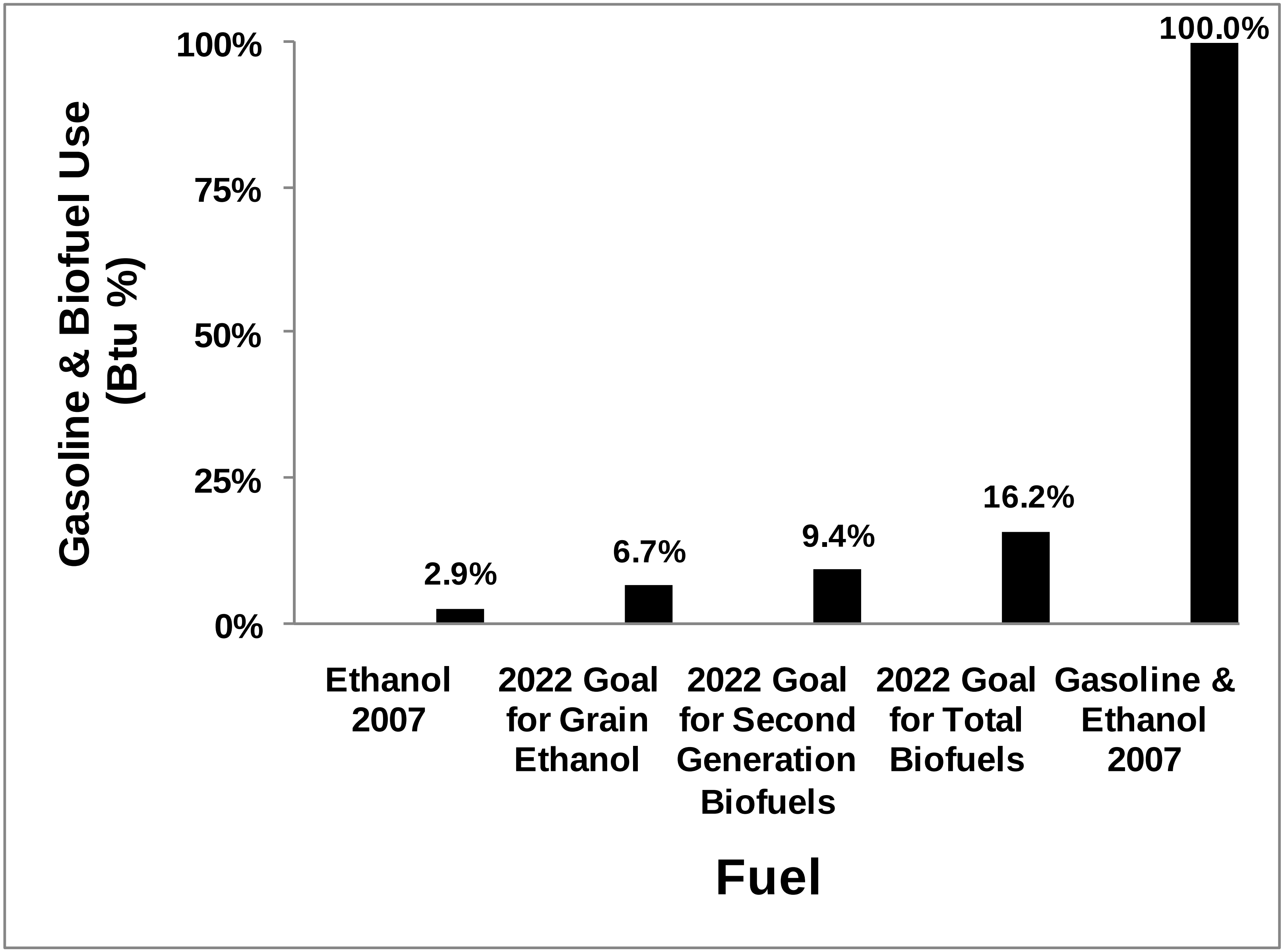
# U.S. Energy Market



# US Gasoline and Ethanol Use



Potential Energy from EISA Mandate for 2022 Relative to 2007 Use



TRANSITION TO A BIO ECONOMY

The Role of Extension in Energy

# Biomass: Producer Choices, Production Costs and Potential

# RFS – 2
## US EPA estimates of feedstock sources to meet 16 B gal of cellulosic 2022 mandates

- 9 B - crop residues
  - **7.8 B - corn stover**
- 3.9 B - forestry biomass
- 2.1 B - urban waste
- **0.9 B - switchgrass** or other dedicated energy crops


Corn Stover

# Corn Stover Cost Estimates

| Source | Year | Location |
|---|---|---|
| English et al. | 1981 | IA |
| Gallagher et al. | 2003 | IA |
| Gallagher et al. | 2003 | KS |
| Graham et al. | 2007 | U.S. |
| Glassner et al. | 1998 | IA |
| Khanna | 2008 | IL |
| Petrolia | 2008 | MN |
| US EPA | 2009 | IN |

# Estimates of Corn Stover Cost

| Source | Location | Harvest ($/ton) | Fertility Replacement ($/t) | Payment to Land Owner/Farmer ($/t) | Harvestable Yield (t/acre) | Farm Gate Cost ($/ton) |
|---|---|---|---|---|---|---|
| Gallagher et al. | KS | $6 | $6 | n.a. | 3.33 | $12 |
| Graham et al. | U.S. | $18 - $33 | $7 | n.a. | 1.4 – 2.3 | $25 - $40 |
| Glassner et al. | IA | $15 | n.a. | $ 3 - $ 15 | 1.5 - 3.0 | $18 - $30 |
| Khanna | IL | $35 | $8 | $24 | 1.85 | $67 |
| Petrolia | MN | n.a. | $4 | n.a. | n.a. | $40 |
| US EPA | IN | $24 | $12 | $10 | 2.00 | $43 - $46 |

Range: $12 - $67 / ton

# Switchgrass

# Switchgrass Cost Estimates

| Source | Year | Location |
|---|---|---|
| Duffy | 2007 | IA |
| Epplin | 1996 | OK |
| Epplin et al. | 2007 | OK |
| Garland | 2008 | TN |
| Khanna | 2008 | IL |
| Khanna et al. | 2008 | IL |
| Perrin et al. | 2008 | ND, SD, NB |
| Vadas et al. | 2008 | WI |
| USEPA | 2009 | |

# Switchgrass Cost Estimates

| Source | Location | Nitrogen (lb/a) | Land Charge ($/ac) | Mature Yield (tons/acre) | Farm Gate Cost ($/ton) |
|---|---|---|---|---|---|
| Duffy | IA | 100 | $80 | 4 | $82 |
| Epplin et al. | OK | 80 | $60 | 3.75-6.50 | $ 37-$ 53 |
| Garland | TN | 60 | n.a. | 6.45 | $ 62 + Land |
| Khanna | IL | n.a | $77 | 2.4 | $113 |
| Khanna et al. | IL | 100 | $78 | 2.58 | $82 |
| Perrin et al. | ND, SD, NB | 67 | $60 | 2.23 | $54 |
| Vadas et al. | WI | 125 | $80 | 4.84 | $53 |
| USEPA | | n.a. | $62 | 6.17 | $44 |

Range: $37 - $113 / ton

# Corn Stover Versus Switchgrass (Farm Gate Cost)

- Corn Stover
  - Range:  $12 - $67 / ton
  - US EPA estimate by 2022 $43-$46

- Switchgrass
  - Range:   $37 - $113 / ton
  - US EPA estimate by 2022 $44

# US EPA Estimates (for 2022) of Average Cost for Flow of Feedstock Throughout the Year

2006 Dollars

- Corn Stover
  - Farm Gate $43-$46
  - Expected Average Total Cost to Biorefinery $89

- Switchgrass
  - Farm Gate $44
  - Expected Average Total Cost to Biorefinery $73

# Corn Stover Versus Switchgrass

- Expected Greater Average Transportation Cost for Stover
  - Expect Lower Removable Yield per Acre
  - Bales Expected to be Less Dense

- Expected Greater Average Storage Cost for Stover
  - Narrow Harvest Window
  - More Land Required
  - More Valuable Land

# Challenges

- Cost efficiency suggests
  - Year-round operation of the biorefinery
  - Year-round delivery of feedstock

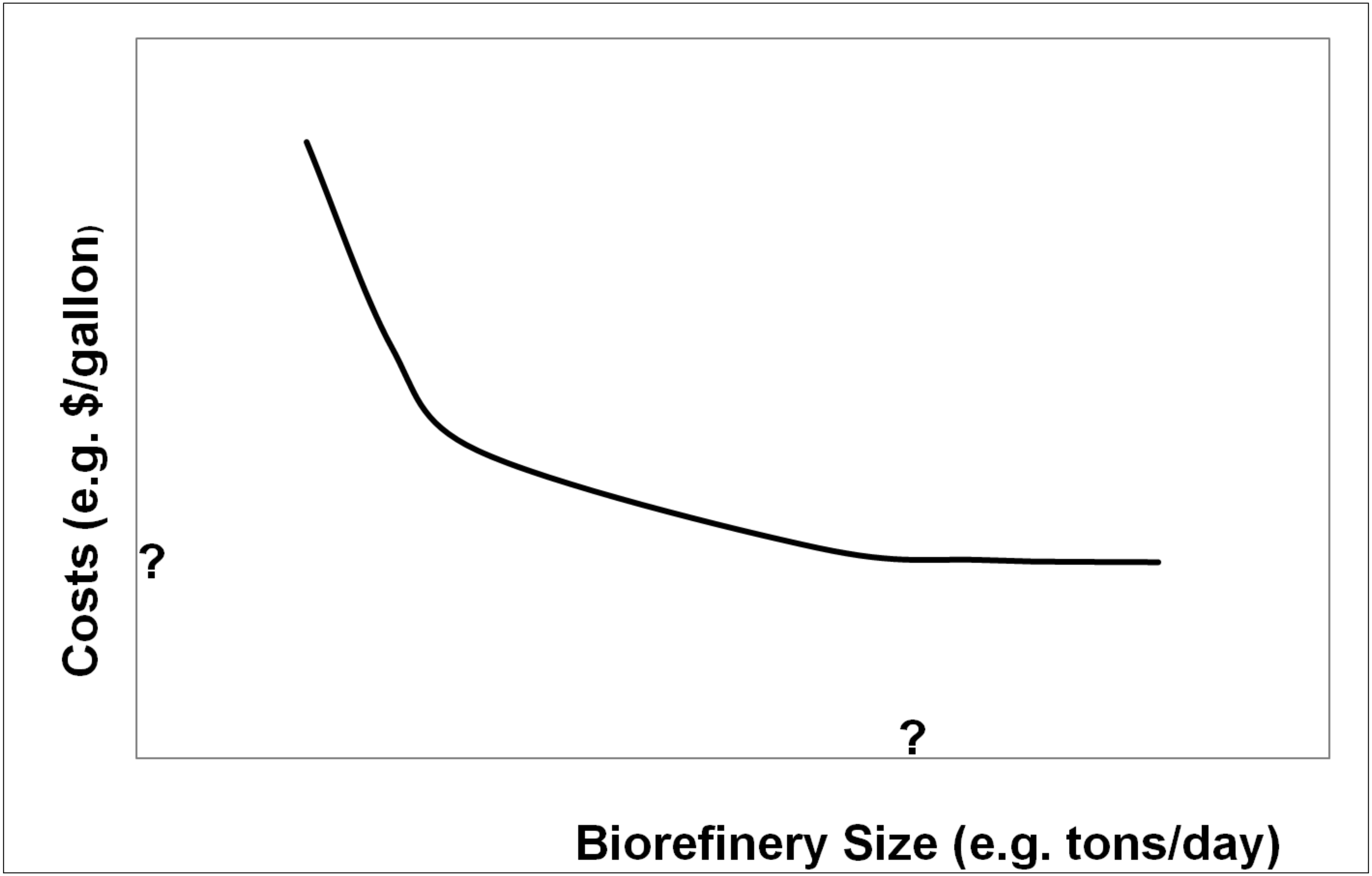
- Optimal size is unknown but 50+ million gallons per year is common for corn ethanol plants

- Anticipate that a cellulosic biorefinery would require 2,000 dry tons per day

# Quantity of Feedstock Required for a 2,000 tons per day Biorefinery

- 700,000 tons of biomass per year
- 350 days of operation per year
- 17 dry tons per truck
- 118 trucks per day
- 24 hours per day
- 4.9 trucks per hour

# Optimal Biorefinery Size



# Feedstock Transportation Cost

# Trouble with Stubble

- collection, storage, and transportation of a continuous flow of corn stover is a "…logistical nightmare…". (Schechinger 2000)

- In the U.S. Corn Belt, stover harvest may be complicated by
  - Rain
  - Mud
  - Snow
  - Fire
  - Stalk moisture retention
  - Narrow harvest window

Source: Schechinger, Tom. Current Corn Stover Collection Methods and the Future. October 24, 2000. Online. Available at http://www.afdc.doe.gov/pdfs/4922.pdf.

# Corn Stover Harvest Window

- 40 days - IN (Nielsen 1995)
- 21 days – MN (Petrolia 2008)
- 50 days – IN (US EPA 2009)
- Abengoa Bioenergy concluded that in 1 of 7 years corn stover harvest is likely to be limited by weather in Eastern Midwest (Robb 2007)

# Dual (Grain & Stover) Harvest Systems

- Expensive
- Grain May be Ready for Harvest but Moisture Content of Stover May be Too High for Safe Storage
- May delay harvest of grain
  - Decrease in Expected Grain Yield
  - Potential Decrease in Grain Quality
    - Potential Decrease in Net Price

# Trouble with Stubble

"Our main concern is $4 / bu corn (worth $750 to $800 an acre)," Johnson (a corn producer) said. “$30 / acre for biomass is a minor concern for our operation.“

Source: Bill Hord, 27 March 2007, Omaha World-Herald

# Will Switchgrass Work ?

Hypotheses

- Not on land suitable for economical production of continuous corn and/or corn-soybeans in rotation

- Perhaps on marginal cropland and cropland pasture (remains to be seen if pasture can be bid from livestock and converted to perennial grasses)

# Grain versus Cellulosic Biomass

**Corn**

- Annual crop
- Spot markets
- Infrastructure exists
- Planting, harvesting, transportation, and storage systems
- Many alternative uses
- Risk management tools (futures markets) in existence
- Farming activities

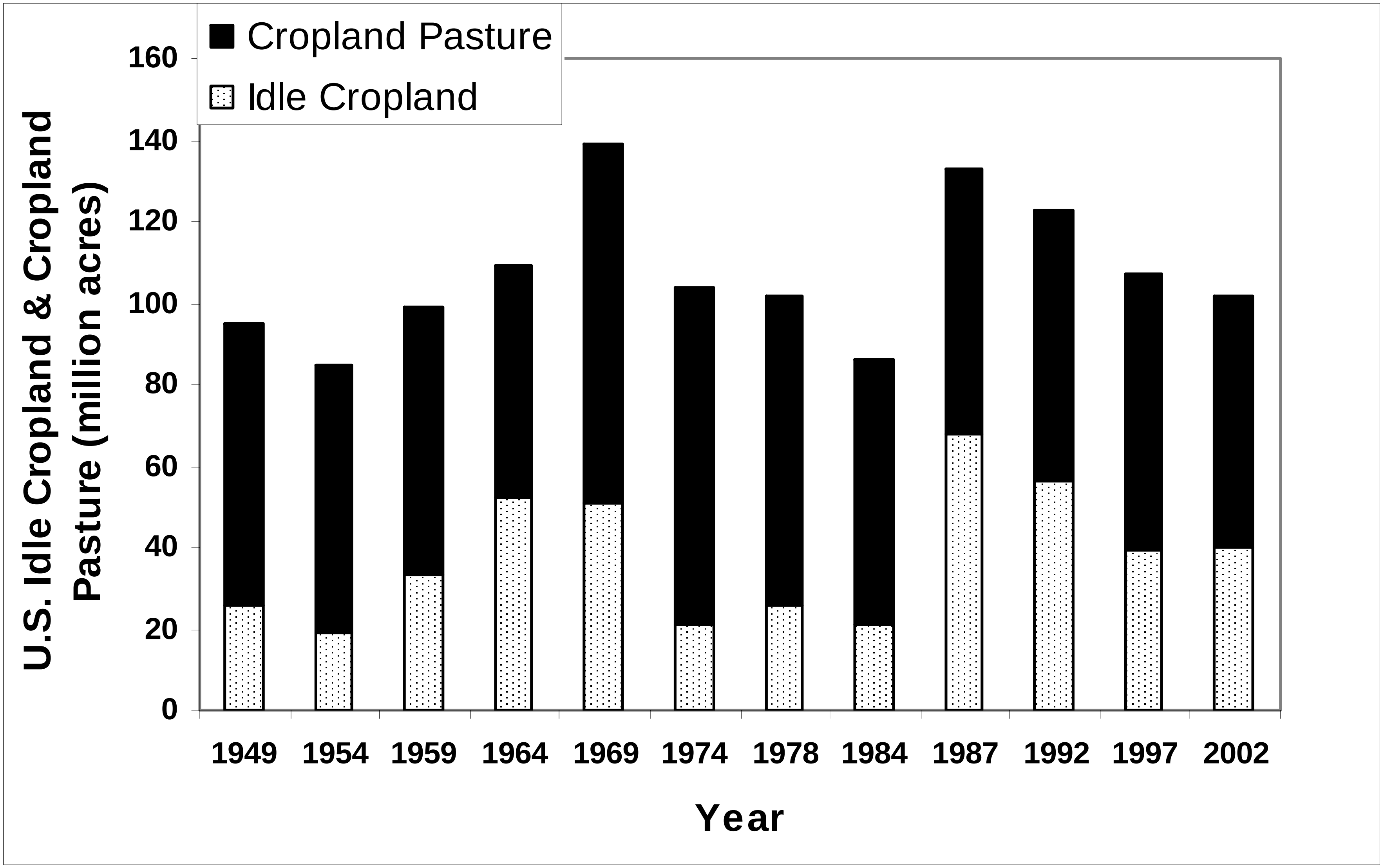
**Switchgrass**

- Perennial
- Zero spot markets
- Zero Infrastructure
- Limited harvesting, transportation, and storage systems
- Few alternative uses for mature switchgrass
- No futures markets
- After established, not much “farming”

# Land ?

"…The rationale for developing lignocellulosic crops for energy is that …poorer quality land can be used for these crops, thereby avoiding competition with food production on better quality land…." (McLaughlin et al. 1999, p. 293).

(Source: McLaughlin, S., J. Bouton, D. Bransby, B. Conger, W. Ocumpaugh, D. Parrish, C. Taliaferro, K. Vogel, and S. Wullschleger. 1999. Developing Switchgrass as a Bioenergy Crop. J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.)




Source: R.N. Lubowski, M. Vesterby, S. Bucholtz, A. Baez, M.J. Roberts. Major Uses of Land in The United States, 2002. USDA ERS Electronic Report Econ. Info. Bul. 14, May 2006.

# Feedstock Acres

- US EPA estimates that by 2022 1.6 million acres of Switchgrass
  - 0.06 NH
  - 0.17 WV
  - 1.34 OK

- In 2007 US farmers planted
  - 94 million acres of corn
  - 64 million acres of soybeans
  - 60 million acres of wheat
  - 11 million acres of cotton

# Potential Markets for Extension Education

- Biorefineries
- Farmers
  - Access to collection and acquisition of corn stover is likely to be controlled by corn farmers rather than land owners
- Land Owners
  - Use of land to establish switchgrass will require interaction with land owners (perhaps similar to CRP)
  - Birefinery will compete with farmers for land

# Issues

- Jed Clampett experience (windfall gain) is not likely
- Biorefineries will seek least-cost feedstock flow
- Potential Danger for Land Owners
  – Contract voided due to bankruptcy
  – After perennial is established, biorefinery could exercise monopsony power

# Abengoa Bioenergy

## Hugoton, KS Facility

(planned 10-yr contracts)

- Propose to contract for acres rather than for a specific crop.
- Farmers/landowners are free to plant wheat, grain sorghum, or corn.
- Contracts grant the option to either purchase or to refuse to purchase crop residue available after grain harvest on contracted acres.
- CRP land (subject to USDA restrictions) may be contracted

# Abengoa

## (planned 10-yr contracts)

$1 / ac paid only in first year - commitment fee

$0.50 / ac / yr as a reservation payment

1. $15 / dry ton
2. $7 plus nutrient replacement cost
3. $10 plus revenue share

   (revenue share = 2.5 * Chicago Board of Trade EtOH

   futures (capped at $10 / ton))
4. $2 plus revenue sharing plus nutrient replacement

Abengoa will be responsible for harvest, transport, and storage

# Potential Role for Government Relative to Establishment of Perennial Crops

- Guarantee or insure payment over the expected life of the crop
- Could use existing CRP infrastructure to facilitate contracting
- CRP was established in 1985
  - By July of 1987 more than 22 million acres were enrolled
- Insurance

# Risk ?

# Challenges to Cellulosic Ethanol

- Economically viable conversion system
- Profitable business model
- Energy is a commodity
  - The least-cost source will be used first
  - In the absence of policy incentives (subsidies, carbon taxes, mandates) extremely difficult to compete with fossil fuels on cost

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