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Future U.S. Biofuels and Biomass Demand – Uncertainty Reigns

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Land is the Limiting Factor

- We could potentially face increasing demands for biomass for biopower and biofuels and demand for land for afforestation.
- We have national objectives relating to production of food, feed, fuel, and environmental amenities.
- Are we asking the same land to provide all of these?

Research Needed

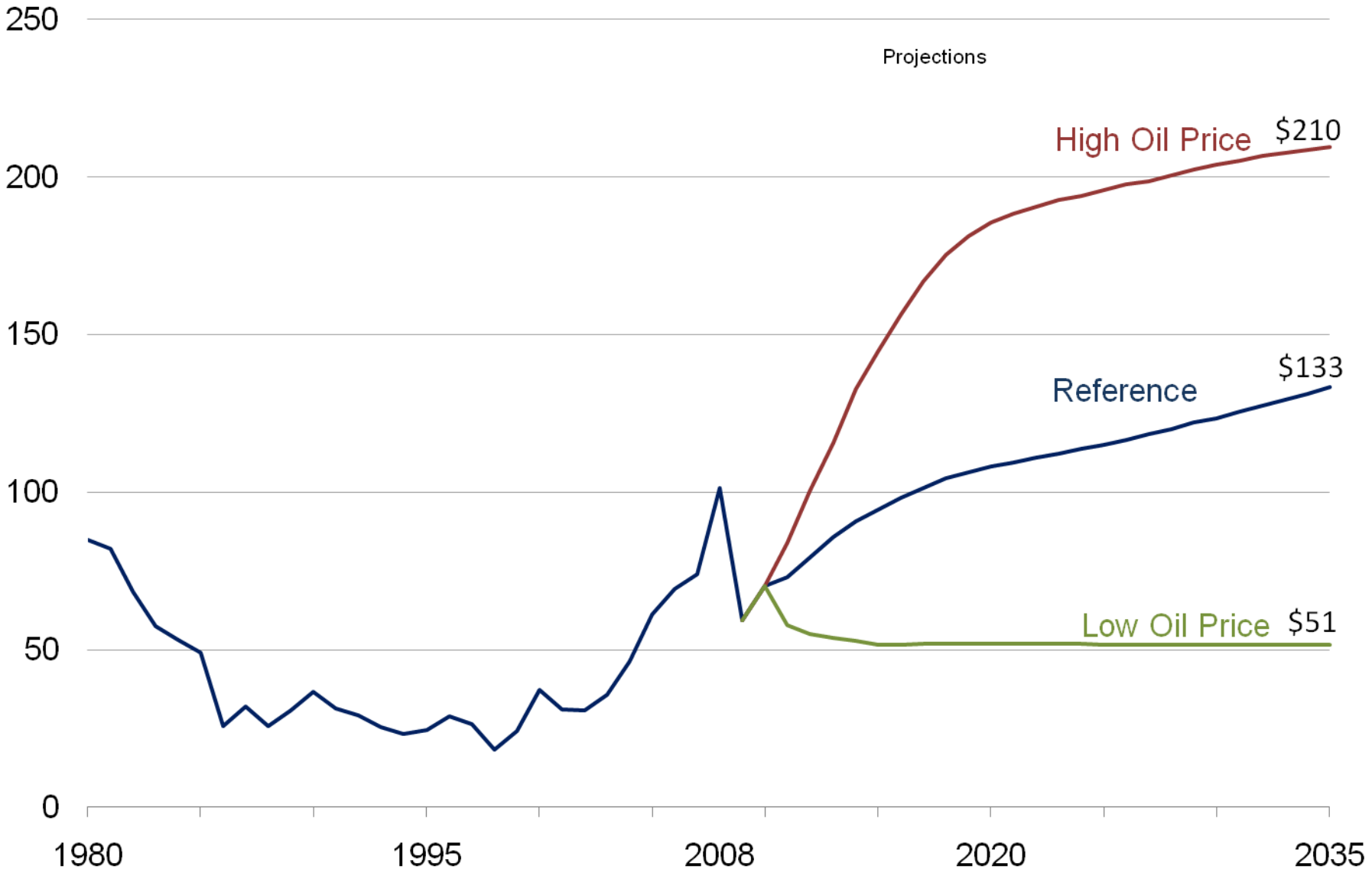
- There has been some research done on this topic, but much more is needed.
  - McCarl and his group have examined these options under different carbon prices and generally find that afforestation and biopower are more attractive than biofuels.
  - Reilly also has done good work in this area, and his results depend on technology assumptions made.

Biofuels Uncertainty

- For cellulosic biofuels there are five major sources of uncertainty:
  - Future oil prices
  - Feedstock costs and availability by region
  - Conversion costs and efficiencies
  - Environmental impacts of biofuels production
  - Government policy
- The combination of all of these makes analysis of biofuels impacts highly uncertain.
- Add in the condition of the financial markets at present, and cellulosic biofuel investment becomes quite problematic.

Average annual world oil prices in three cases, 2005-2035

2008 dollars per barrel



Feedstock Costs and Supply

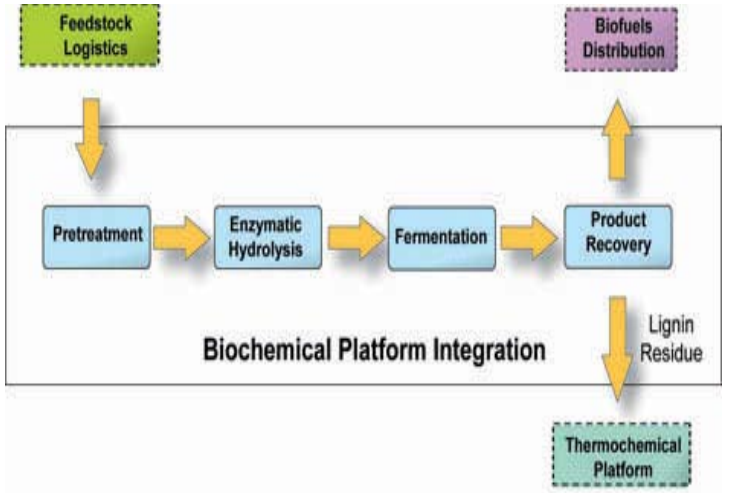
- For years, DOE used a cellulosic feedstock cost of $30/dry ton.
- Today we expect that corn stover may be more like $75 and dedicated energy crops closer to $100 per dry ton.
- The 2009 NAS study estimated feedstock availability might be 416-548 mil. tons, less than half the bil. ton study number.
- That is still more than enough to meet the cellulosic RFS.

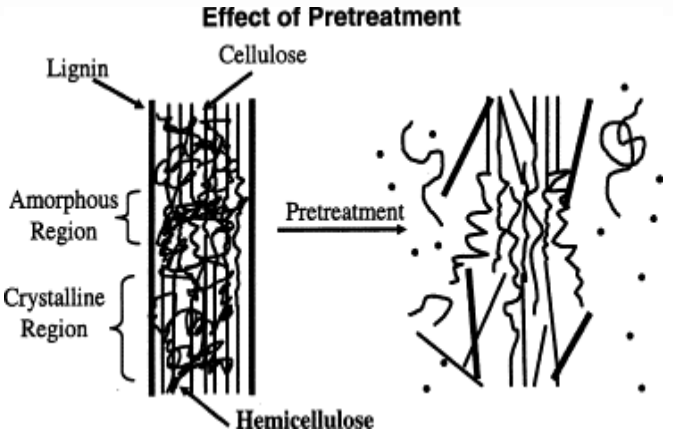
Feedstock Costs and Supply

- In all likelihood, cellulosic biomass will be contracted long term.
  - Dedicated energy crops produce 10 years or more.
  - We are still working on contracting mechanisms that meet the needs of both farmers and conversion facilities.
  - The basic issue is how to index and share risks associated with the production and delivery.

Biochemical Conversion

- End product is usually ethanol
- A process that is similar to that of producing corn ethanol
- Pretreatment
  - Separates the cellulose and hemicellulose from the lignin, which creates rigid plant cell walls
- Hydrolysis
  - Breaks down complex chains of sugar molecules into simple sugars (hexoses and pentoses)
- Fermentation
  - Turns simple sugars into liquid fuels using yeast strains
- Distillation
  - Concentrates ethanol
- Use of Lignin
  - Lignin can be recovered and used for plant heat, to created electricity to power the plant, or passed through thermochemical conversion to produce gasoline or chemicals.

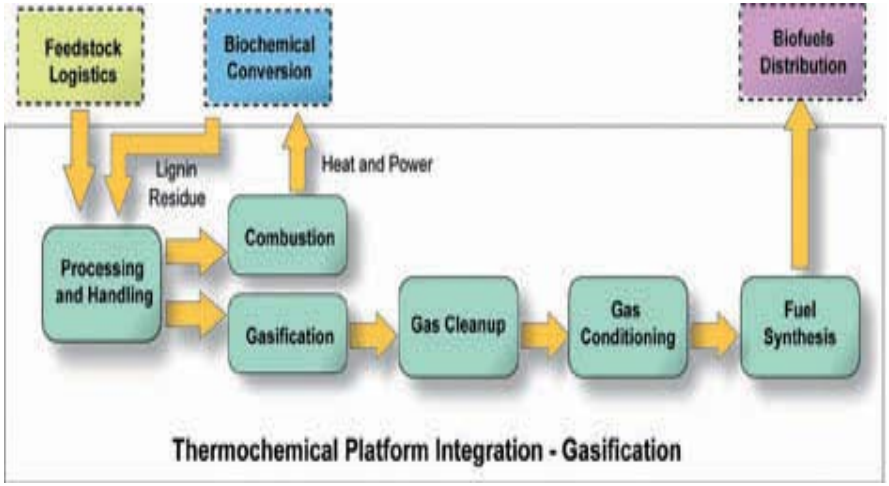




Thermochemical Conversion

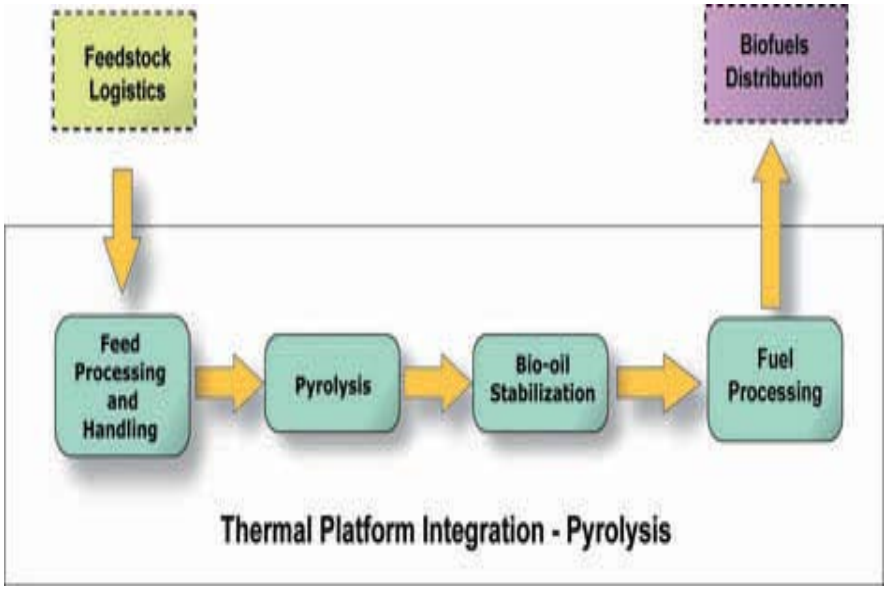
End product is gasoline or diesel

- Uses heat to decompose the feedstock
- Gasification
  - Biomass is dried to less than 20% moisture
  - Partial combustion of biomass at 700°C in anaerobic conditions produces synthesis gas
  - Fischer-Tropsch process to produce gasoline and diesel
  - Requires more cleanup and conditioning to ensure that the gasoline is pure
    - This problem is made more severe when using biomass.



Thermochemical Conversion

- End product is gasoline or diesel
- Uses heat to decompose the feedstock
- Pyrolysis
  - Partial combustion of biomass at 450°C to 600°C in anaerobic conditions produces bio-oil, which is similar to crude oil.
  - Bio-oil is refined into gasoline and diesel



Conversion Costs

- Most estimates put the cost for biofuels from either biochemical or thermochemical conversion above $3/gal. gasoline equivalent.
- Generally we need about $120 oil to make cellulosic biofuels competitive on a market basis with no government intervention.

Environmental Impacts

- The environmental impacts of cellulosic biofuels could be positive, as they create wildlife habitat and can reduce soil erosion.
- Of late, there has been some concern about possible local loss of biodiversity. This could arise if a biofuel plant were surrounded up to fifty miles by mostly miscanthus or switchgrass.

Government Policy

- Blend wall
- RFS enforcement
- Subsidy mechanism
- Reverse auctions
- Key is to reduce uncertainty for private sector investors

Blend Wall

- Currently we have E10 and E85 ethanol blends, but E85 is miniscule, so most ethanol is consumed as E10 or a lower blend.
- At that blending %, our max consumption is 12-12.5 billion gallons. If the blending % stays at 10, then we cannot exceed that level of ethanol from any source.
- The recent EPA proiposed change to 15% for 2001+ vehicles if implemented would shift the blend wall to 19 bil. gal..

Impacts of Blending Wall on Cellulose

- So long as corn and sugarcane ethanol are less expensive to produce than cellulosic ethanol, there is little room for cellulosic ethanol. Corn ethanol or imported sugarcane ethanol would supply the quantity needed up to the wall – **even if the limit is increased to 15%.**
- For infrastructure and blend wall reasons, “drop-in” biofuels may be more attractive.

Cellulose RFS Issues

- In their February 2010 final ruling, the EPA effectively converted the US RFS from a volumetric to an energy basis.
  - They interpret the RFS as 36 billion gallons of ethanol equivalent.
  - This means that a gallon of bio-gasoline or ester biodiesel would count as 1.5 gallons, and a gallon of non ester bio-diesel counts as 1.7 gallons.
  - If the entire 36 billion gallons were met with bio-gasoline, it would amount to 24 billion physical gallons.
- The big remaining RFS issue is enforcement uncertainty.

Subsidy Mechanisms

- In December 2010 Congress extended the biofuel subsidies until end of 2011.
- Many different options are being discussed and evaluated:
  - Variable subsidy
  - Two part subsidy
  - Remove subsidy and import tariff
  - Subsidy only on portion over RFS
  - Subsidy based on biofuel energy content

Reverse Auction

- With all the uncertainty in the market today, investors are reluctant to make the plunge.
- With a reverse auction, government or military would auction the procurement of biofuels with long-term contracts.
  - Eliminates price uncertainty
  - Presumably bidders would take into account their feedstock and conversion costs
  - Other government policies less of an issue

Biofuels Potential

- We have the resource base to meet the RFS and beyond for cellulosic biofuels.
- The costs will be higher than previously estimated, but likely economic at $120 crude oil, or lower with subsidies.
- The five uncertainties loom large in the near term as they inhibit private sector investment.
- Reverse auction might get early plants built.

Biofuel Conclusions

- All the renewable fuel policy options are now on the table.
- Alternatives to the fixed subsidy will be explored this year, such as variable subsidy, energy based subsidy and others.
- Cellulose biofuels will not come on without strong incentives or a credible mandate.
- The blend wall is the biggest barrier faced by the ethanol industry in the United States today.

Thank you!
Questions and Comments

For more information:

http://www.ces.purdue.edu/bioenergy

http://www.agecon.purdue.edu/directory/details.asp?username=wtyner