First and Second Generation Biofuels: Economic and Policy Issues

Wally Tyner

With Input from

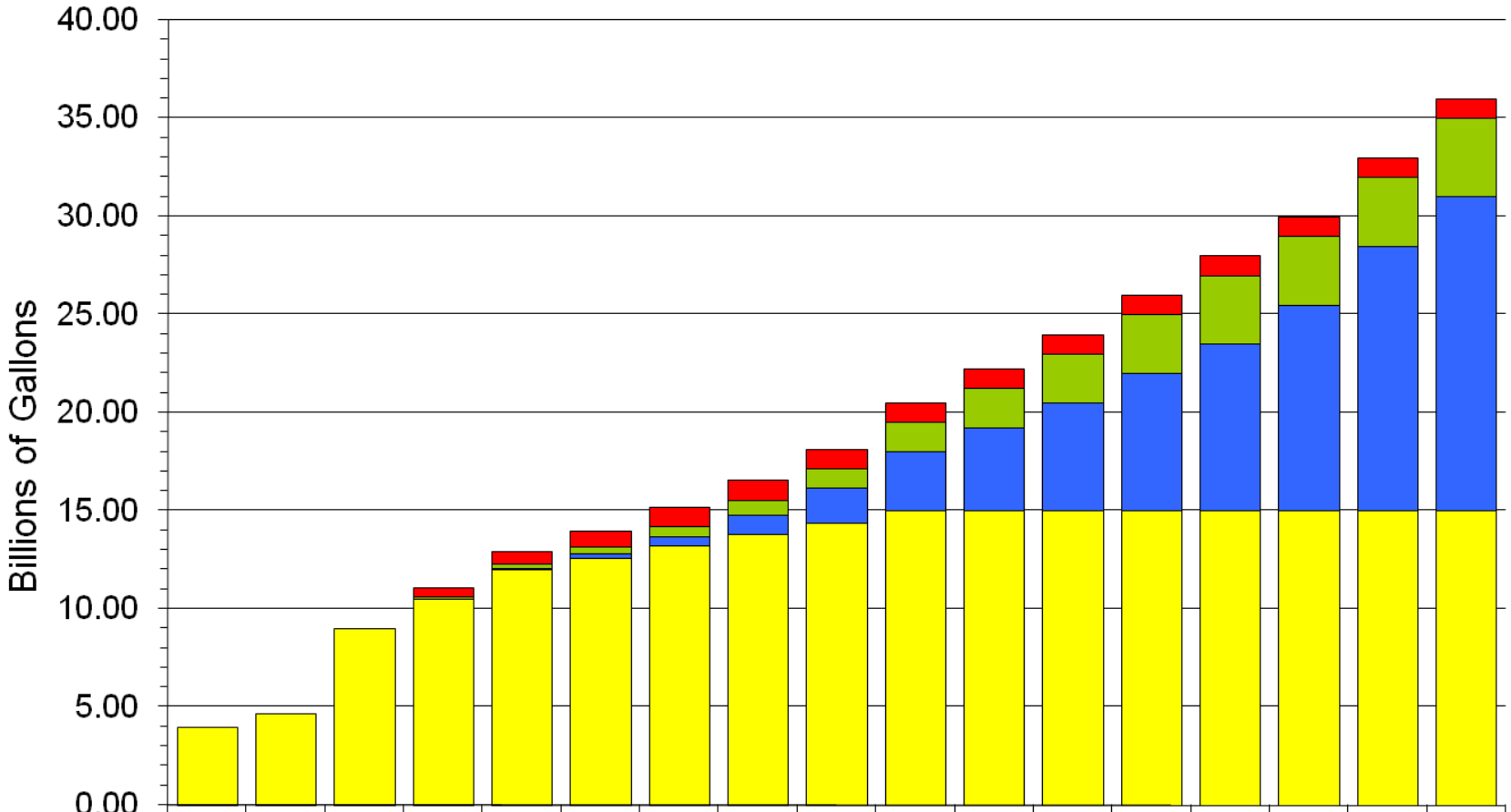
Craig Rismiller, Daniela Viteri, Sarah Brechbill, David Perkis, and Farzad Taheripour

December 1, 2009

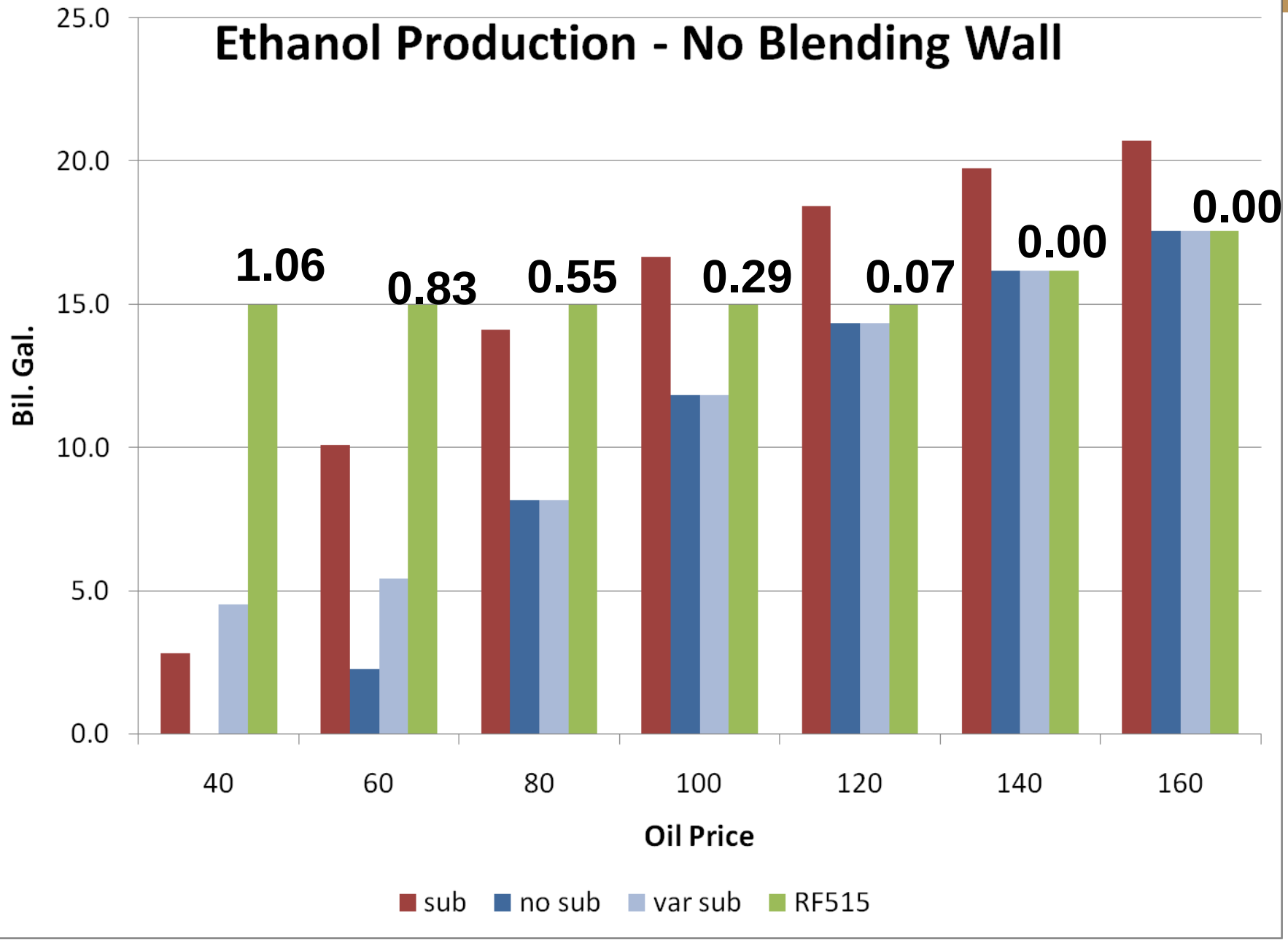
Policy Simulations for Corn Ethanol

- We simulate the following policies:
  - 45 cent/gallon ethanol subsidy
  - No ethanol subsidy
  - A variable ethanol subsidy beginning at $70 oil and increasing $0.0175 for each dollar crude falls below $70
  - A renewable fuel standard of 15 billion gallons for corn

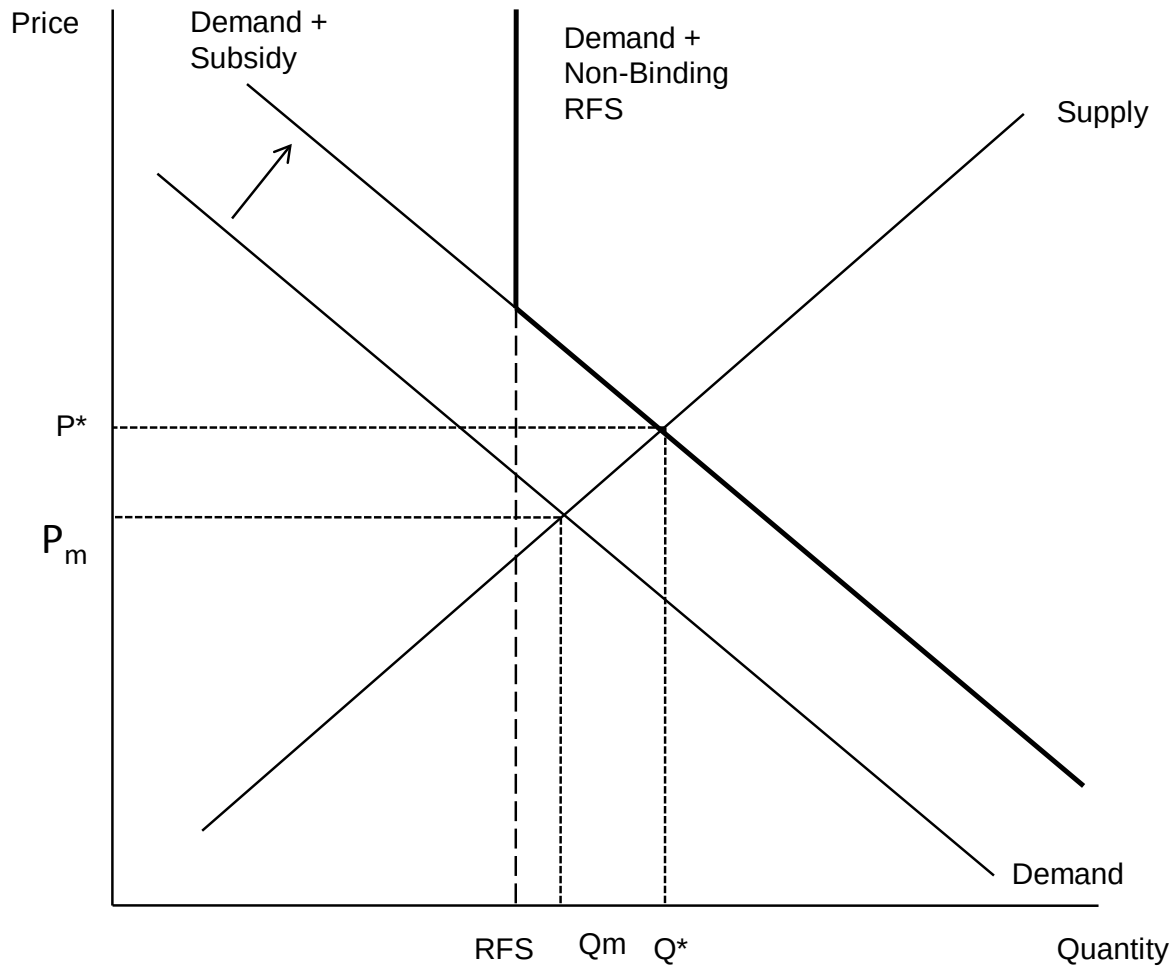
Renewable Fuel Standard



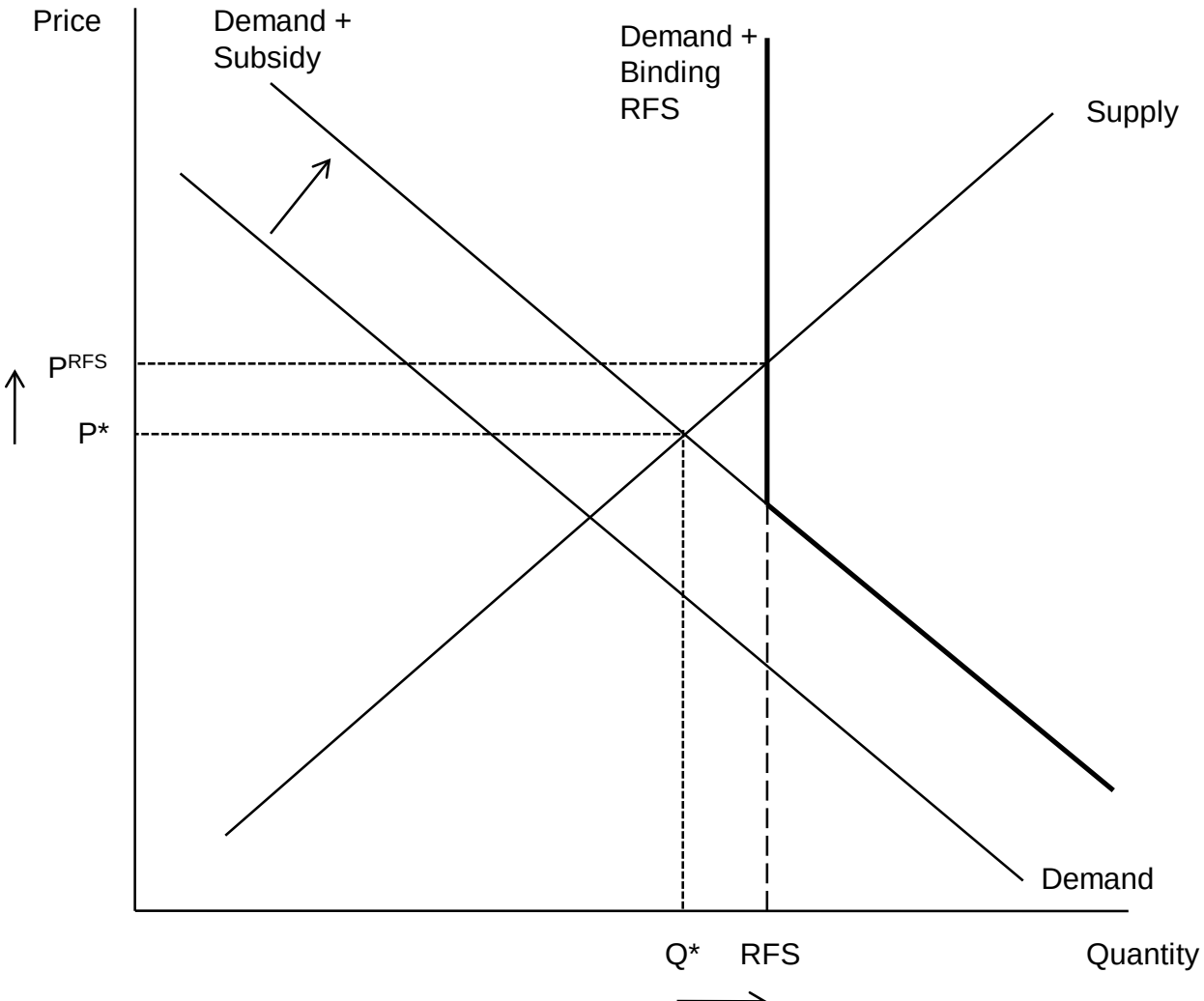
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Biomass-based Diesel				0.50	0.65	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Non-celulosic Advanced				0.10	0.20	0.30	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	3.50	3.50	4.00
Celulosic Advanced					0.10	0.25	0.50	1.00	1.75	3.00	4.25	5.50	7.00	8.50	10.5	13.5	16.0
Conventional Biofuels	4.00	4.70	9.00	10.5	12.0	12.6	13.2	13.8	14.4	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0


Ethanol Production - No Blending Wall
25.0
20.0
15.0
10.0
5.0
0.0
Bil. Gal.
1.06
0.83
0.55
0.29
0.07
0.00
0.00
40
60
80
100
120
140
160
Oil Price
sub
no sub
var sub
RF515

Subsidy with Non-binding RFS

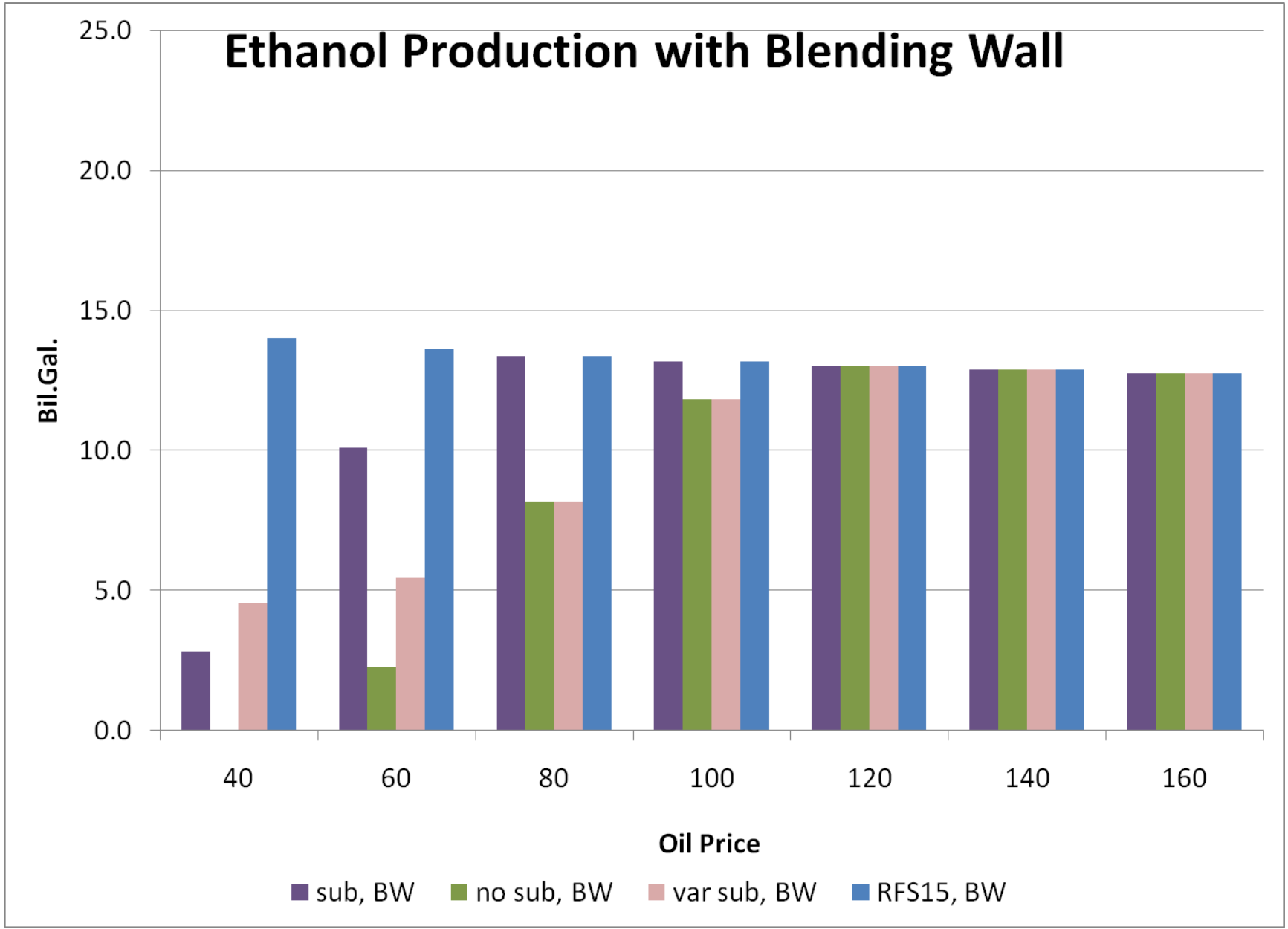


Binding Ethanol RFS

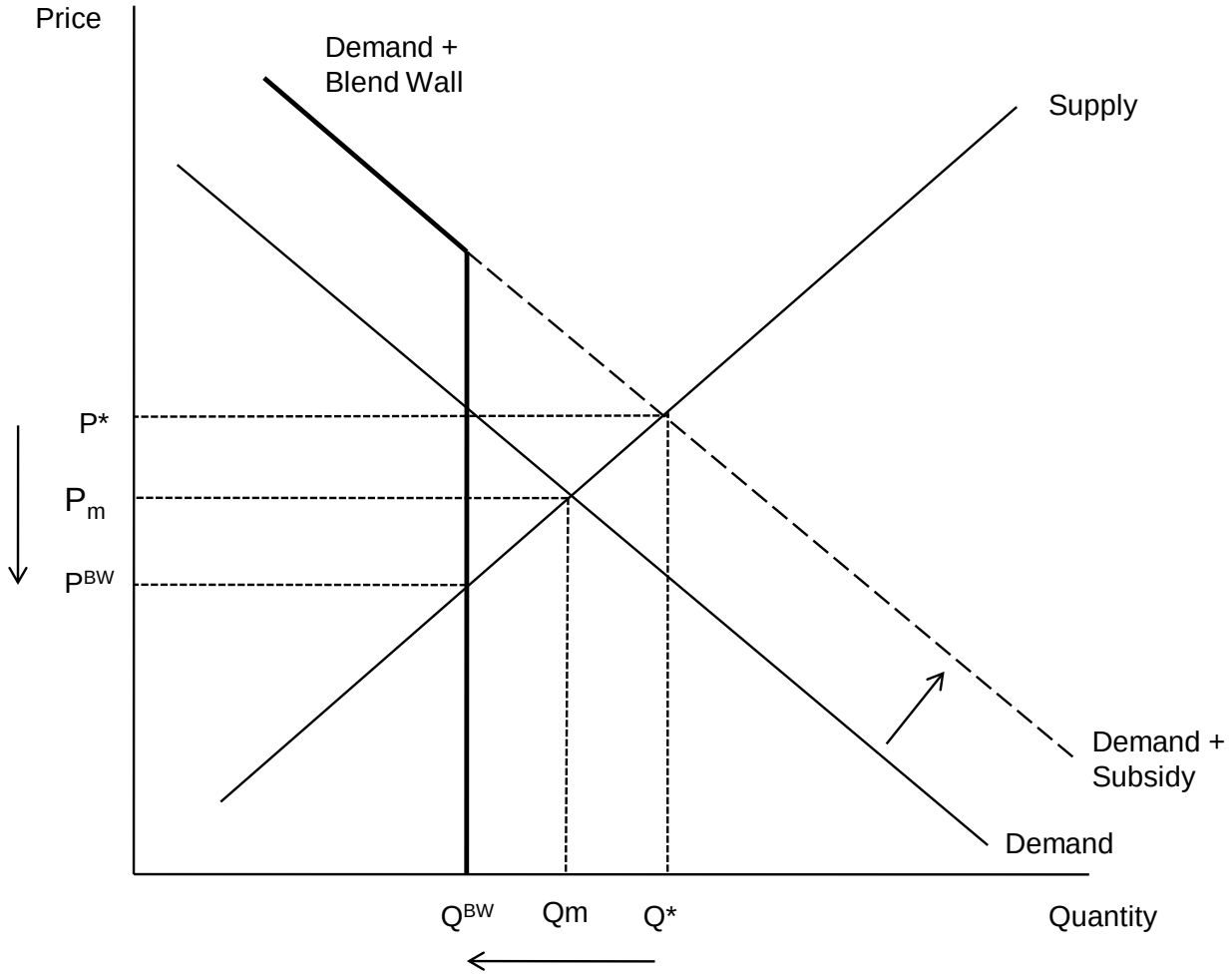


The Blend Wall

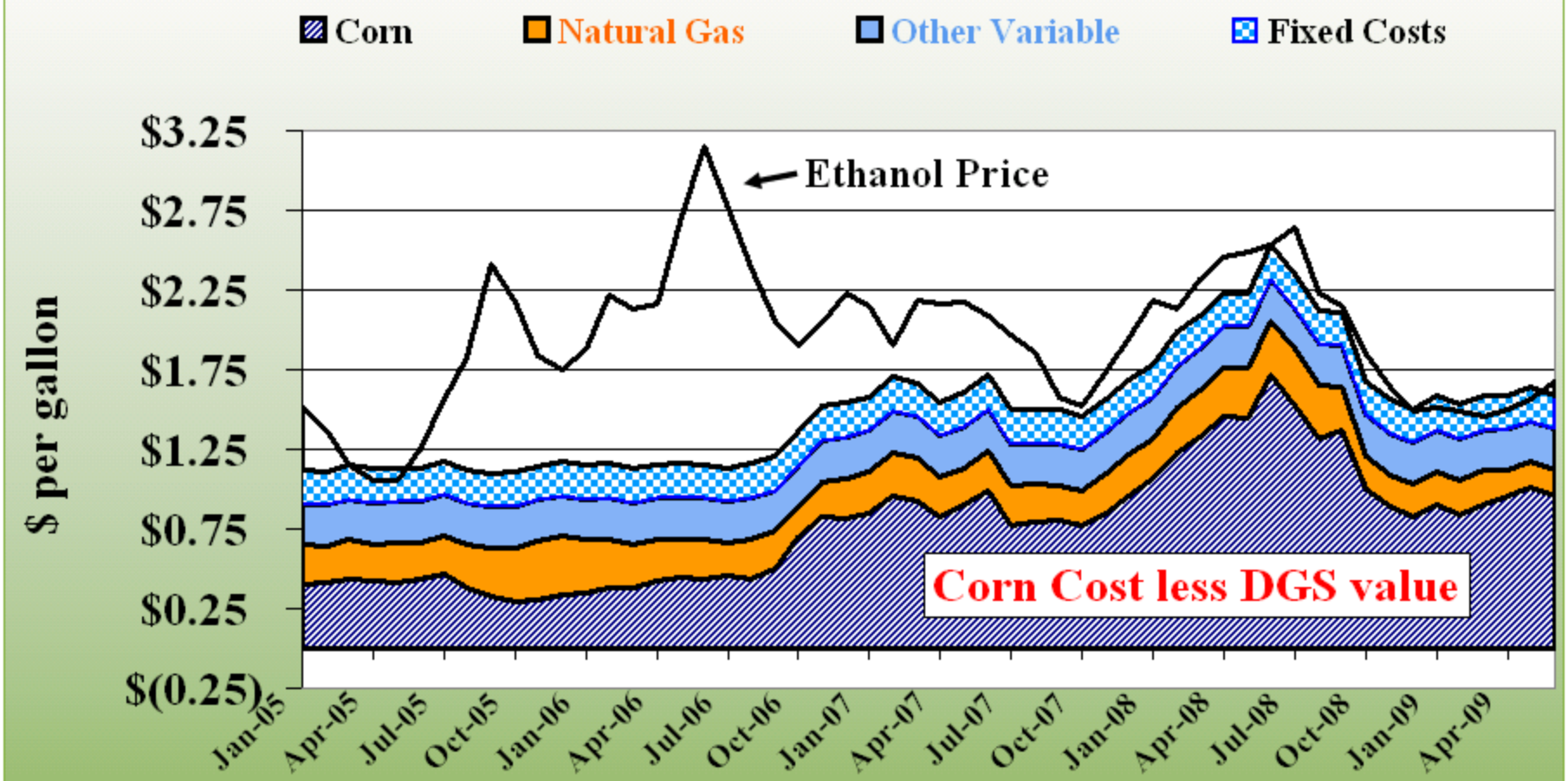
- We consume about 140 billion gallons of gasoline type fuel annually, so a 10% blend limit would be a max of 14 billion gallons of ethanol
- However, the effective blend limit is much lower
- At the wall, there is more ethanol capacity than market absorptive capacity, so ethanol price falls
- Ethanol price falls to the breakeven with corn for the marginal producer that just meets the wall limit


Ethanol Production with Blending Wall
25.0
20.0
15.0
10.0
5.0
0.0
Bil.Gal.
40
60
80
100
120
140
160
Oil Price
sub, BW
no sub, BW
var sub, BW
RFS15, BW

Blending Wall

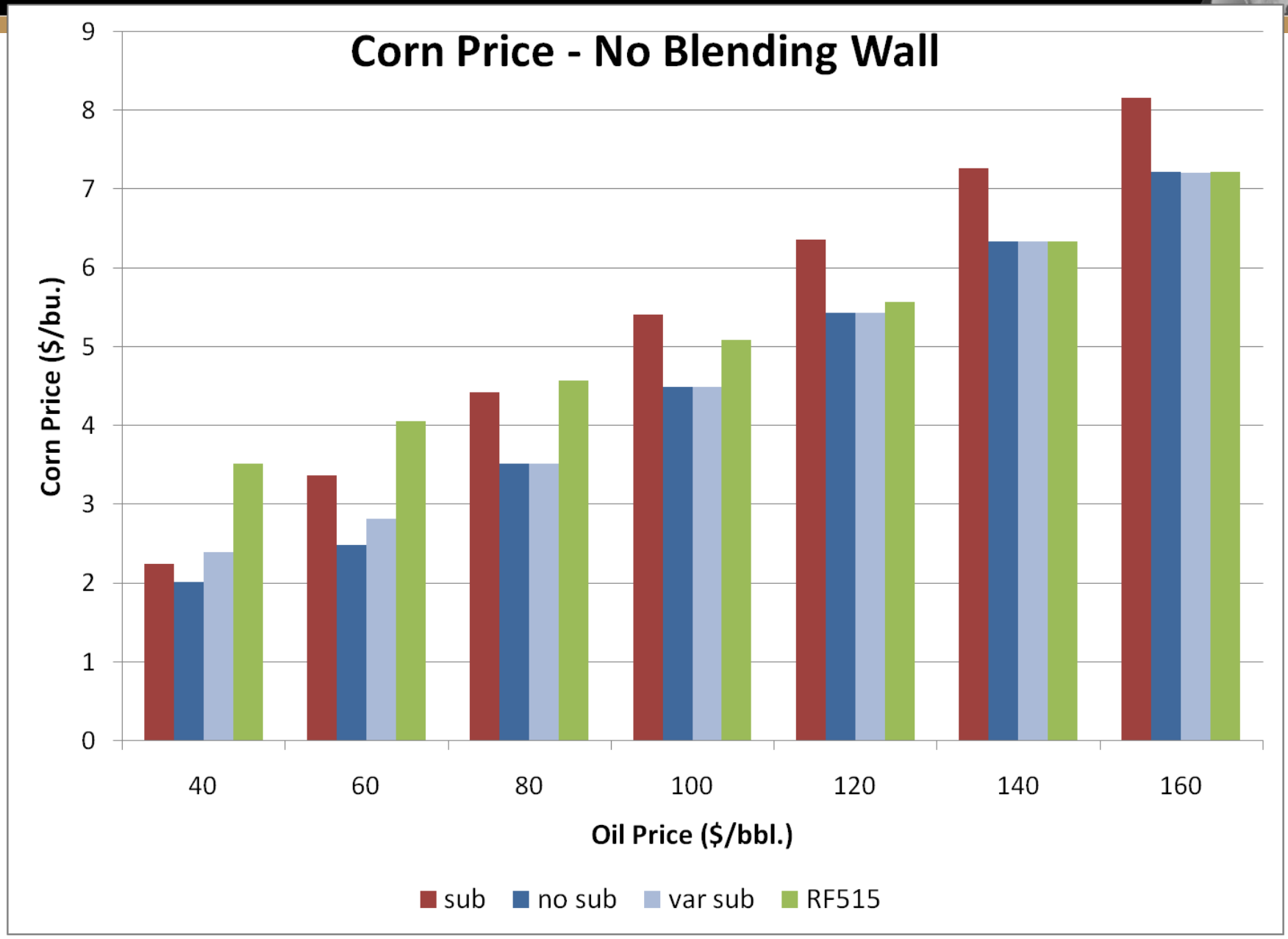


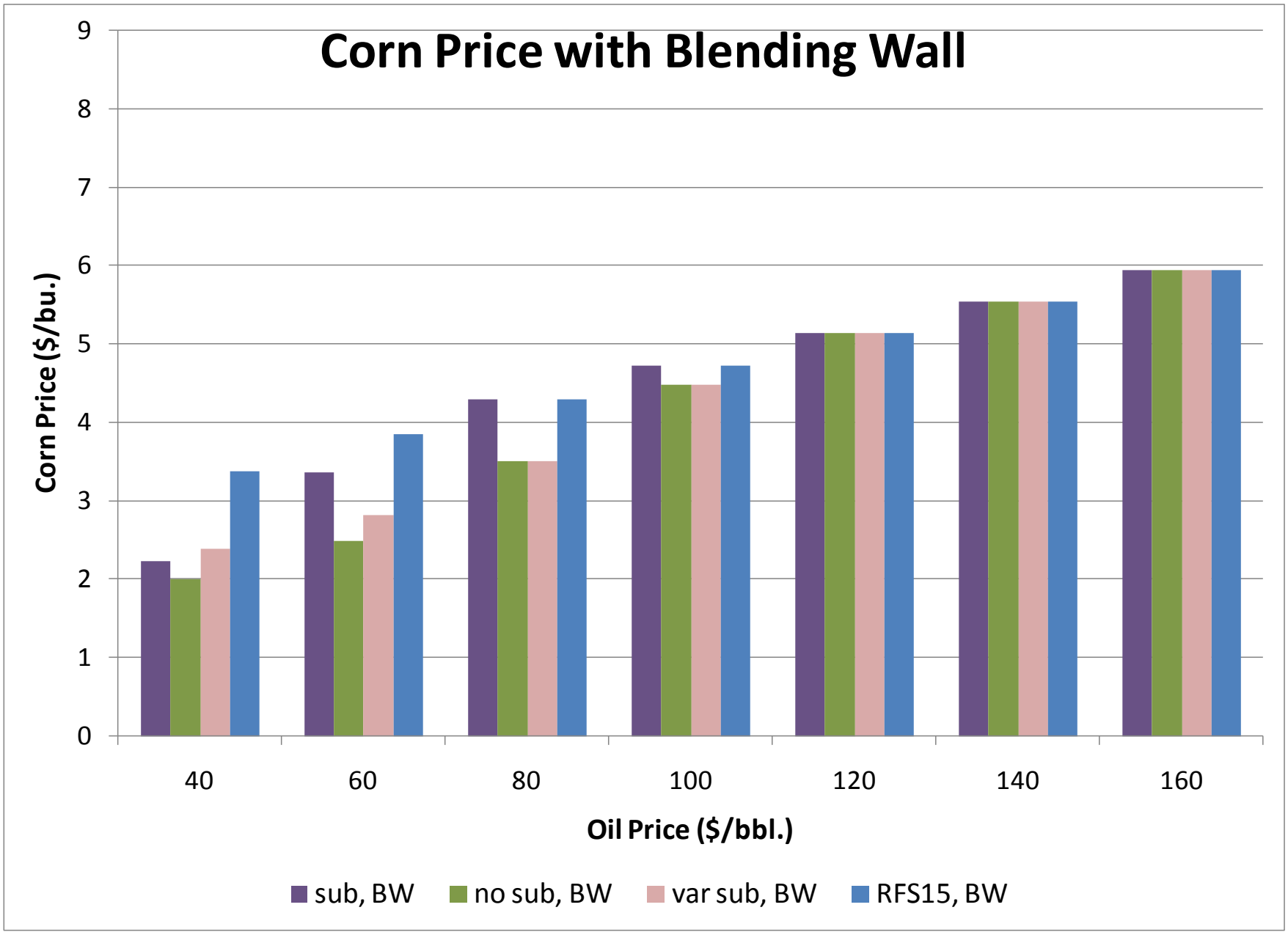
Ethanol Break-even Price, $/gal. & Ethanol Price, With Credit for DGS Value, Using Spot Prices



Source: Iowa Ethanol Report, EIA

From Bob Wisner, Iowa St


Corn Price - No Blending Wall
Corn Price ($/bu.)
0
1
2
3
4
5
6
7
8
9
40
60
80
100
120
140
160
Oil Price ($/bbl.)
sub
no sub
var sub
RF515

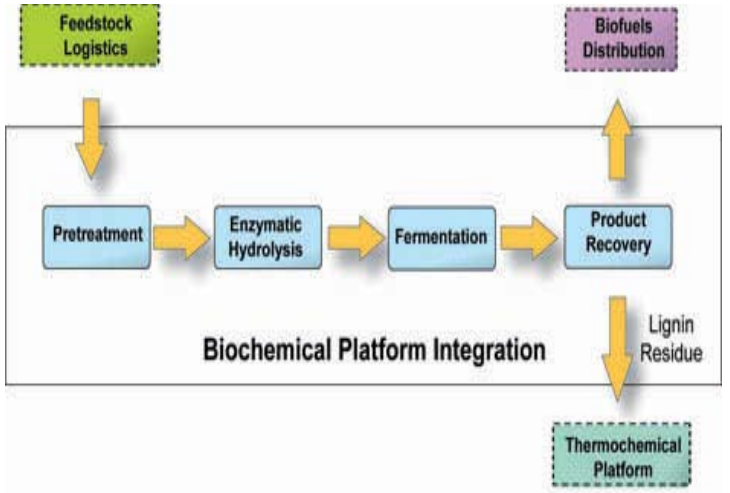

Corn Price with Blending Wall
Corn Price ($/bu.)
0
1
2
3
4
5
6
7
8
9
40
60
80
100
120
140
160
Oil Price ($/bbl.)
sub, BW
no sub, BW
var sub, BW
RFS15, BW

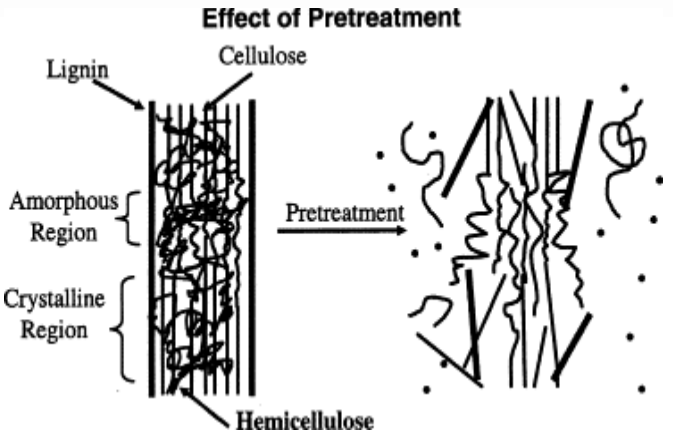
Second Generation Conversion Processes

- A wide variety of conversion processes are being investigated for second generation biofuels
- In our economic modeling to date, we have a biochemical process producing ethanol and a thermochemical process producing bio-gasoline directly.
- Our data is from public sources (ARS, NREL, etc.), so it does not include proprietary advances.

Biochemical Conversion

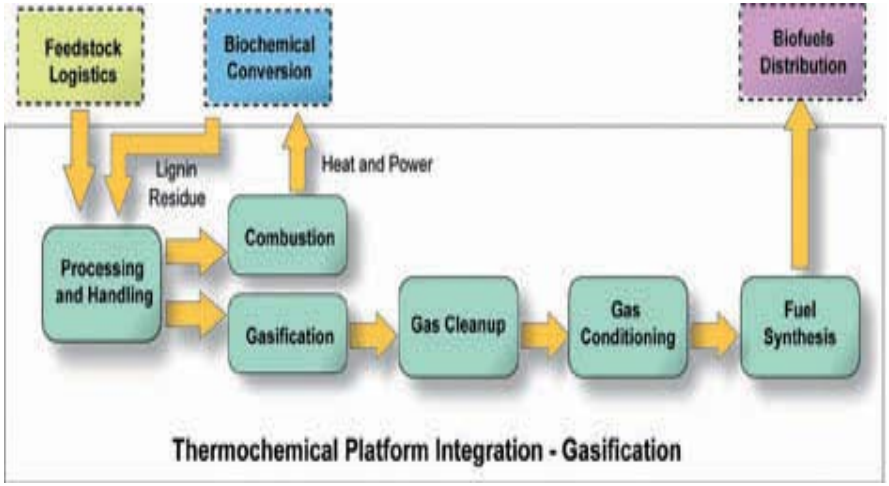
- End product is usually ethanol
- A process that is similar to that of producing corn ethanol
- Pretreatment
  - Separates the cellulose and hemicellulose from the lignin, which creates rigid plant cell walls
- Hydrolysis
  - Breaks down complex chains of sugar molecules into simple sugars (hexoses 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.





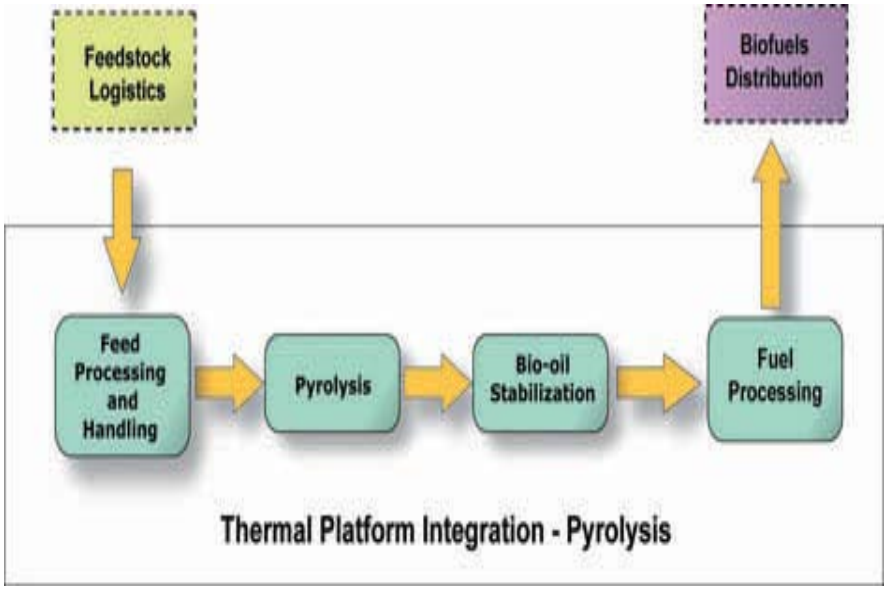
Thermochemical Conversion

- 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



Production Costs

- Cost estimates are constantly changing as the technology develops. These estimates include capital and operating costs.
- In order for cellulosic biofuels to reach commercialization, the production cost per gallon must be reduced.

- Biochemical
  - $2.27 to $2.98 per gallon of gasoline eqv.
- Ways to reduce cost
  - Make pretreatment more efficient
  - Reduce enzyme costs
  - Make fermentation more efficient with a single strain of yeast that can ferment both hexoses and pentoses

- Thermochemical
  - $2.28 to $3.15 per gallon of gasoline eqv.
- Ways to reduce cost
  - Reduce the need for cleaning and conditioning by eliminating tar, ash, and other impurities.
  - Adding hydrogen to reduce cost by increasing yield

EPA Issued Draft Rules for RFS on May 5

- Corn ethanol has a requirement for a 20% reduction, but the average industry technology ranged from +5% to -16%, so corn would not meet the rule under the draft regulation
- However, all existing plants are grandfathered, so there is little real world impact of that finding.
- The draft reg will be subjected to peer review.

EPA Issued Draft Rules for RFS on May 5

- Cellulose based biofuels must meet a 60% GHG reduction standard in the RFS.
- EPA found that switchgrass ethanol reduced GHG 124 to 128 percent. Miscanthus would be similar or better.
- EPA found that corn stover ethanol reduced GHG from 115 to 116 percent.
- Bottom line is all second generation feedstocks meet the RFS when producing ethanol and likely hydrocarbons as well.

Second Generation Economic and Policy Issues

- Blending wall
- Import tariff
- Market uncertainty
- Technology uncertainty
- Feedstock supply
- Interaction among all these factors

Import Tariff

- There is currently an import tariff on ethanol of 54 cents per gallon plus 2.5% of value, which yields a total tariff of about 59 cents/gal.
- The current corn ethanol subsidy is 45 cents, considerably lower than the import tariff.
- The cellulose subsidy is $1.01.
- The tariff is not independent of the subsidies or the RFS.

Blending 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.
- This limit would eliminate the bioochemical pathway or any 2nd generation process that produced ethanol as its output.

Impacts of Blending Wall on Cellulose

- So long as corn ethanol is less expensive to produce than cellulosic ethanol, which is likely to be the case, even for the long term, there is no room for cellulosic ethanol. Corn ethanol would supply the quantity needed up to the wall.
- If blenders needed to meet a cellulose RFS, it is not clear what they would do. Fuel blenders can buy cellulose biofuel RINs for the max of $0.25 or ($3.00 – RBOB), in lieu of blending.

Blend Wall Impacts

- Suppose corn ethanol is $1.75, RBOB is $2, and cellulose ethanol is $3.
- Blenders can buy a cellulose RIN for $1, and use corn ethanol at $1.75 for a total cost of $2.75, instead of buying cellulose ethanol for $3.
- What blenders would do depends on these three prices plus other market conditions.
- It is likely that the blend wall would impede investment in cellulose ethanol. Even if the blend limit is raised to 15%, there is not much room for cellulose.

Cellulose RFS Issues

- The European RFS is based on energy content. The target is 10% of the energy content of liquid fuels by 2020.
- The U.S. RFS is volumetric with, at present, all biofuels getting the same RFS credit regardless of their energy content.
- Since ethanol has lower energy content than bio-gasoline or bio-diesel, equal volumetric credit favors ethanol over bio-hydrocarbons.

RFS Credit Based on Energy

- If we assume ethanol would receive 1 RIN, then on an energy equivalent basis, the other biofuels would receive:
  - Bio-gasoline 1.48 RINS
  - Bio-diesel 1.65 RINS
  - Bio-butanol 1.25 RINS
- It is energy content basically that determines miles per gallon and imported oil displaced.

Cellulose Subsidies

- The current cellulosic biofuel subsidy is $1.01 per gallon, set to expire in 2012. That subsidy also could be made a function of the energy content of the biofuel.
- In addition, it is possible to let the subsidy vary with the price of crude oil, so that the subsidy is provided when it is needed and taken away when it is not needed.
- For cellulosic biofuels, the subsidy would be needed at least up to oil at $120/bbl.

Cellulose Options

- Subsidy that varies with oil price and energy content ($120, 0.0175 indexed on bio-gasoline):

Crude Price	Ethanol	Bio-Gasoline	Bio-Diesel	Bio-Butanol
40	0.94	1.40	1.55	1.18
60	0.71	1.05	1.16	0.88
80	0.47	0.70	0.76	0.59
100	0.24	0.35	0.39	0.29
120	0	0	0	0
140	0	0	0	0

Market Uncertainty

- Market uncertainty can be handled through government policy. Alternatives include:
  - Fixed subsidy
  - Variable subsidy
  - Purchase contract - auctioned
  - Loans and grants
- Given current policy, market, and finance conditions, investments will **not** be made in second generation biofuel plants

Technological Uncertainty

- All of the processes have a high degree of technical uncertainty.
- While in most cases, it is known that we can produce energy products using the technology, the question is at what cost.
- In the future, we will be incorporating technical uncertainty into our analyses.

Feedstock Supply

- Biomass supplies for 2nd generation fuels can come from residues, annual crops, or perennials (switchgrass or miscanthus)
- Crop residues likely will be the cheapest resources starting around $40/dry ton
- Perennials likely will cost $60/dry ton or more.
- They are produced over 10 year periods or longer, so there will be contracting issues to be resolved.

Conclusions on Costs

- Corn Stover
  - Costs are lower because it is a secondary crop
  - Management decisions will change costs
- Switchgrass
  - As a primary crop, there are higher costs compared to corn stover due to more required inputs and activities
- Supply
  - Location! Location! Location!
  - Corn stover will be more sought after due to lower cost
- Individual producer characteristics and resources will drive decision to produce biomass
  - Uncertainty in production will lead to plants contracting supply
- Ways to reduce costs include equipment innovation, yield increases, and more efficient management

Cellulose Biofuel Issues

- Oil price uncertainty – cellulose biofuels uneconomic below about $120 oil
- Technological uncertainty – both biochemical and thermochemical processes uncertain
- RFS implementation uncertainty – multiple off-ramps may render RFS less than iron-clad
- Current US subsidy and RFS policy is biased towards ethanol; EU policy is technology neutral
- Raw material supply and contracting

Biofuel Conclusions

- All the renewable fuel policy options will be on the table in 2009/10.
- May see more interest in variable incentives because they cost less and do not have as many adverse consequences.
- 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.

Thank you!

Questions and Comments

For more information:

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

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