Biofuels raised in the Greenhouse
An Economic Perspective

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Sources of Support

USDA DOE
USEPA
CSiTE

Topics of the day

Biofuels and GHGs

Biofuel economics

- Effects of energy price and GHG incentives
- Sector effects

An Aside

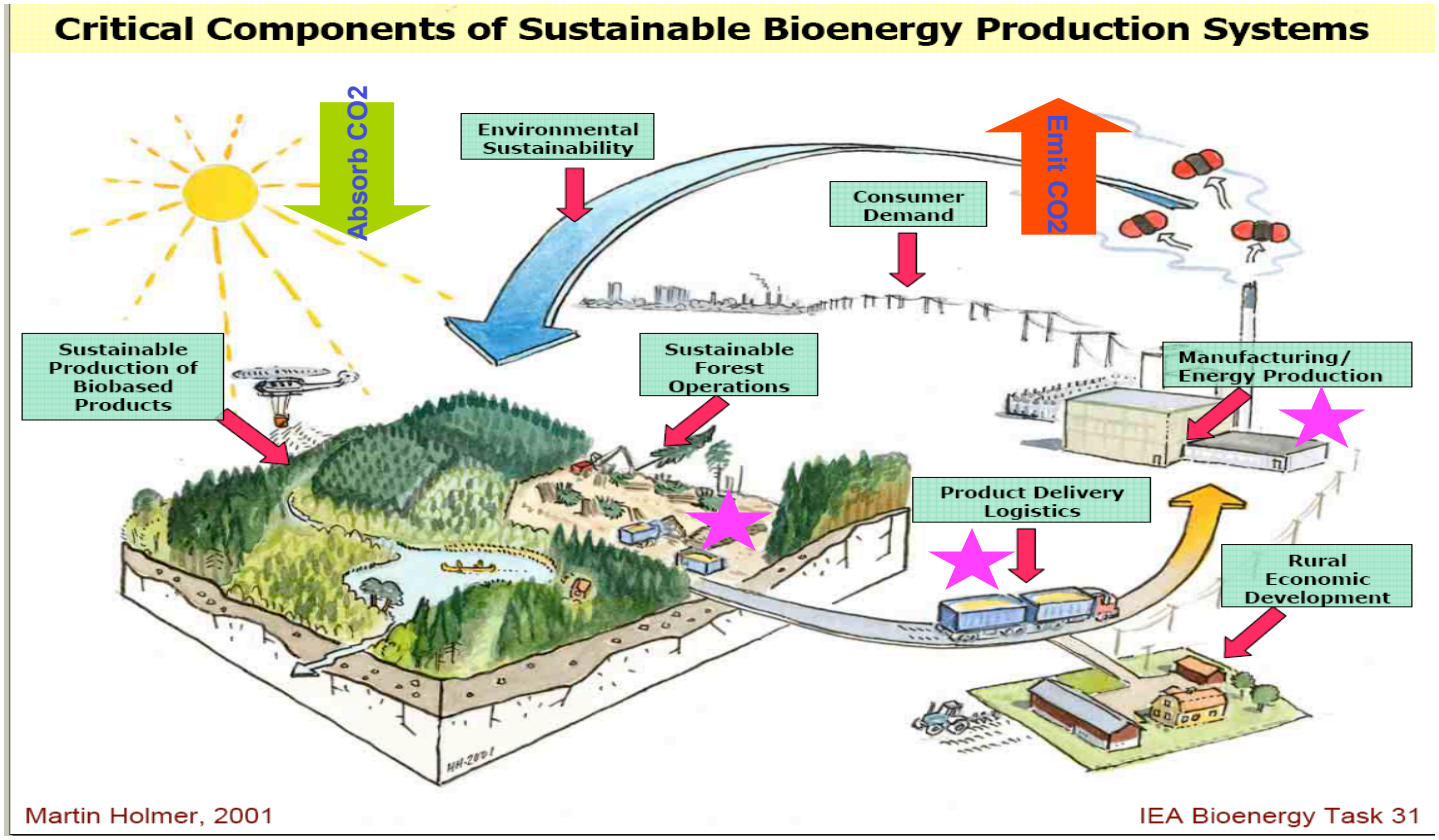
From a GHG perspective

Biofuels ≠ Ethanol

Particularly corn or sugar ethanol

GHG offset = a1 * crop ethanol
+ a2 * cell ethanol
+ a3 * biodiesel
+ a4 * bio fueled electricity

Greenhouse Gasses and Biofuels



Please Pretend the growing stuff includes crops

Feedstocks take up CO2 when they grow then CO2 is emitted when feedstocks burned or when energy derivatives burned

But Starred areas also emit

In total they increase emissions but recycled on net

Source of underlying graphic: Smith, C.T. , L. Biles, D. Cassidy, C.D. Foster, J. Gan, W.G. Hubbard, B.D. Jackson, C. Mayfield and H.M. Rauscher, "Knowledge Products to Inform Rural Communities about Sustainable Forestry for Bioenergy and Biobased Products", IUFRO Conference on *Transfer of Forest Science Knowledge and Technology,* Troutdale, Oregon, 10-13 May 2005

Offset Rates Computed Through Lifecycle Analysis

Net Carbon Emission Reduction (%)

	Ethanol	BioDiesel	Electricity
Corn	25%	50%	
Soybeans		71%	
Sugarcane	65%		
Switchgrass	50%		80-90%
Bagasse	85%		95%
Corn Residue	70%		85-90%
Manure			95-99%
Lignin			85-95%

Ethanol offsets are in comparison to gasoline

Power plants offsets are in comparison to coal.

Electricity offsets higher when cofired due to Efficiency and less hauling

Opportunities have different potentials

Forces stimulating biofuels?

Modeling Approach

McCarl Project Goals

- **Examine the portfolio of land based biofuel possibilities**
- **Bring in a full cost and GHG accounting**
- **Look at motivations for their use in terms of energy prices, and GHG mitigation strategies**
- **Look comparatively across many possibilities including Afforestation, Forest mgt, Biofuels, Ag soil, Animals, Fertilization, Rice, Grassland expansion, Manure, Crop mix**
- **Look at market, energy price, time and technology conditions under which strategies dominate**
- **Look at market effects and co benefits/ costs**

FASOMGHG Mitigation Options

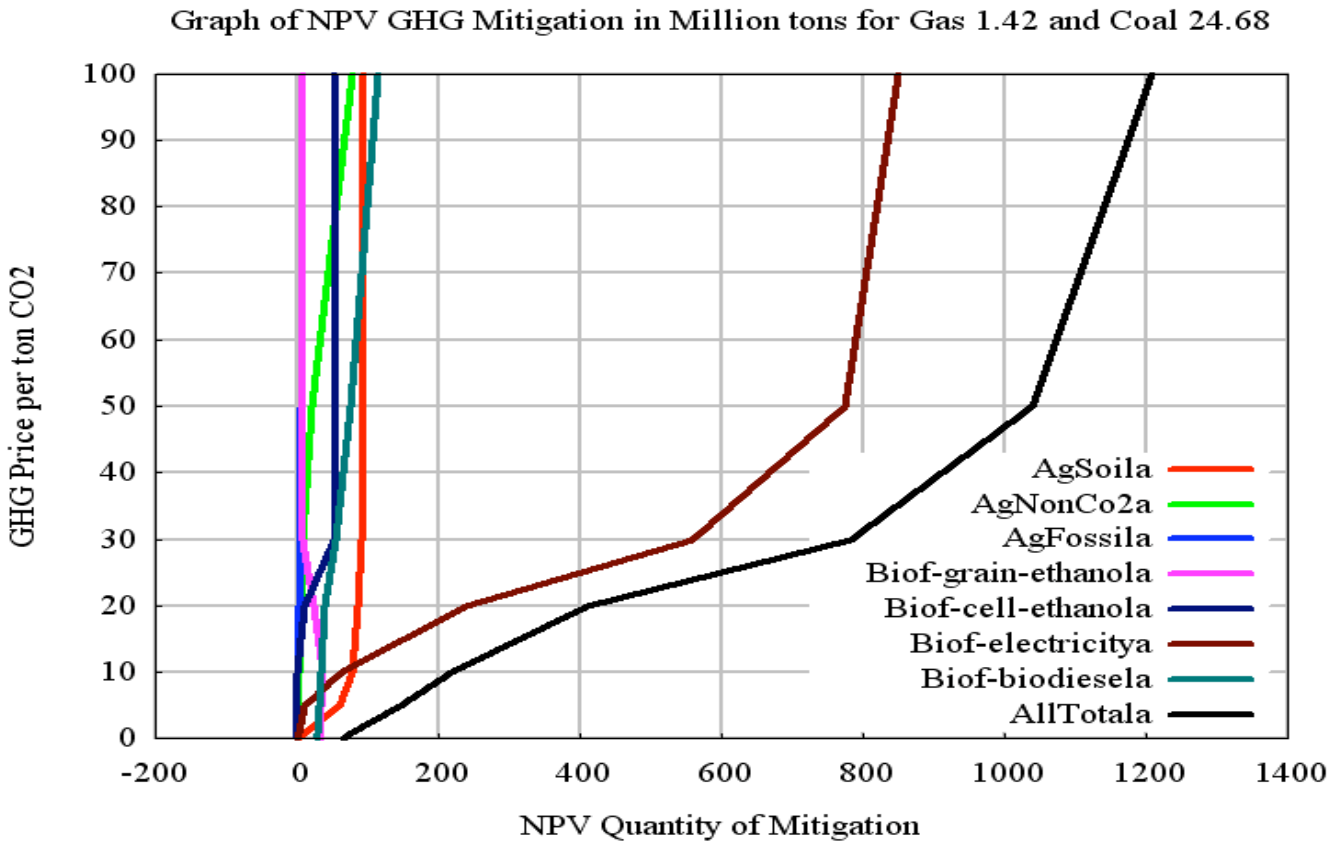
Strategy	Basic Nature	CO2	CH4	N2O
Crop Mix Alteration	Emis, Seq	X		X
Crop Fertilization Alteration	Emis, Seq	X		X
Crop Input Alteration	Emission	X		X
Crop Tillage Alteration	Emission	X		X
Grassland Conversion	Sequestration	X		
Irrigated /Dry land Mix	Emission	X		X
Ferment Ethanol Production	Offset	X	X	X
Cellulosic Ethanol Production	Offset	X	X	X
Biodiesel Production	Offset	X	X	X
Bioelectric Production	Offset	X	X	X
Stocker/Feedlot mix	Emission	X		
Enteric fermentation	Emission	X		
Livestock Herd Size	Emission	X	X	
Livestock System Change	Emission	X	X	
Manure Management	Emission	X	X	
Rice Acreage	Emission	X	X	X
Afforestation	Sequestration	X		
Existing timberland Manage	Sequestration	X		
Deforestation	Emission	X		
Forest Product Choice	Sequestration	X		

Biofuel feedstocks and products

	Ethanol	Cell Ethanol	BioDiesel	Electricity
• Agricultural and forestry products:				
– Corn, Wheat, Sorghum, Rice	X			
– Sugar Cane	X			
– Timber		X		X
• Production residues:				
– Crop Residue		X		X
– Logging Residue		X		X
– Manure				X
• Processing products and by products:				
– Bagasse		X		X
– Soybean/Corn Oil			X	
– Rendered Animal Fat			X	
– Milling Residue		X		X
– Yellow Grease			X	
• Energy crops:				
– Switchgrass		X		X
– Willow		X		X
– Hybrid Poplar		X		X

- Cell ethanol is prospective we don't really have to know how to do at scale
- Electricity may be cofired

Portfolio Composition



Energy prices increases with CO2 price

Ag soil goes up fast then plateaus and even comes down

Why – Congruence and partial low cost

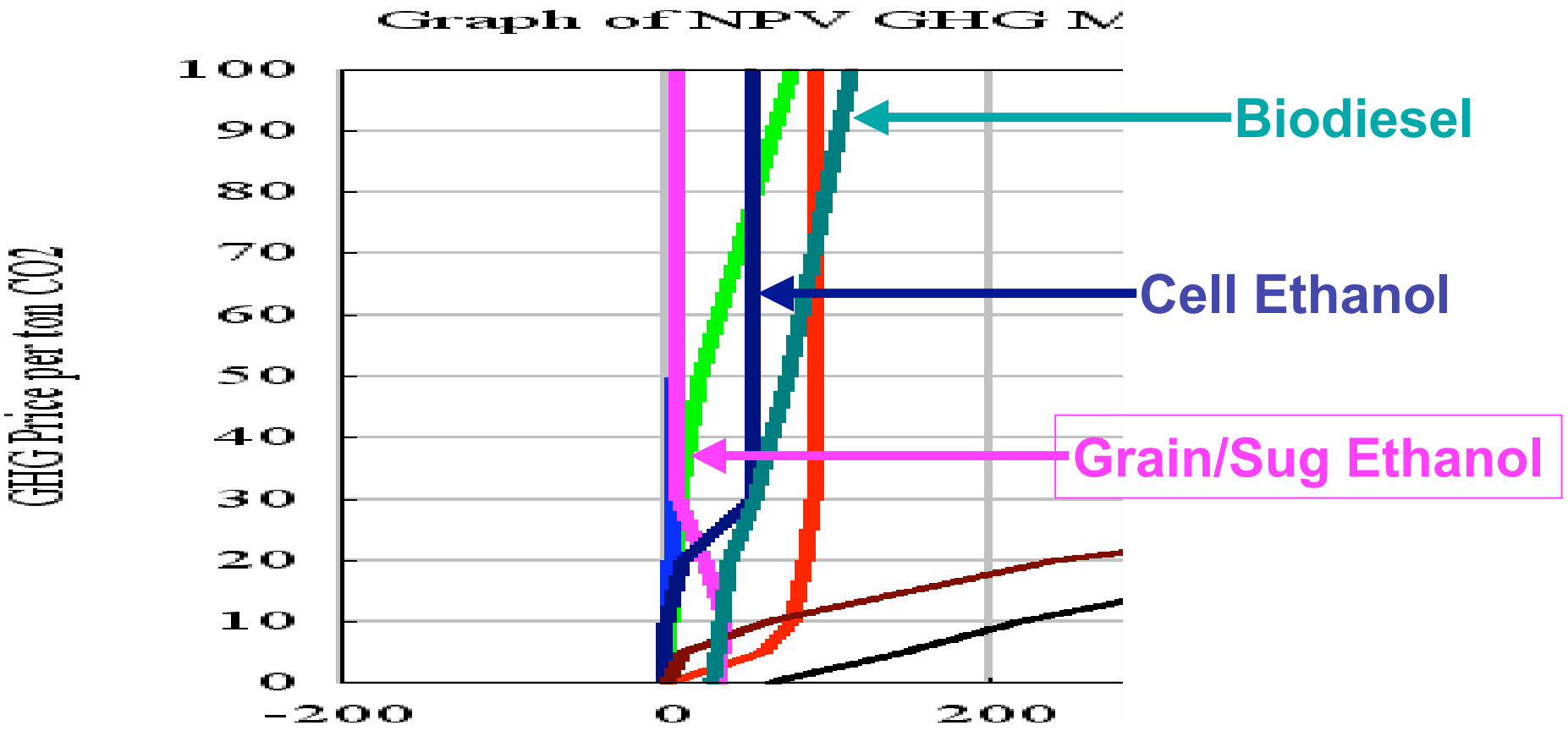
Lower per acre rates than higher cost alternatives

Biofuel takes higher price but takes off

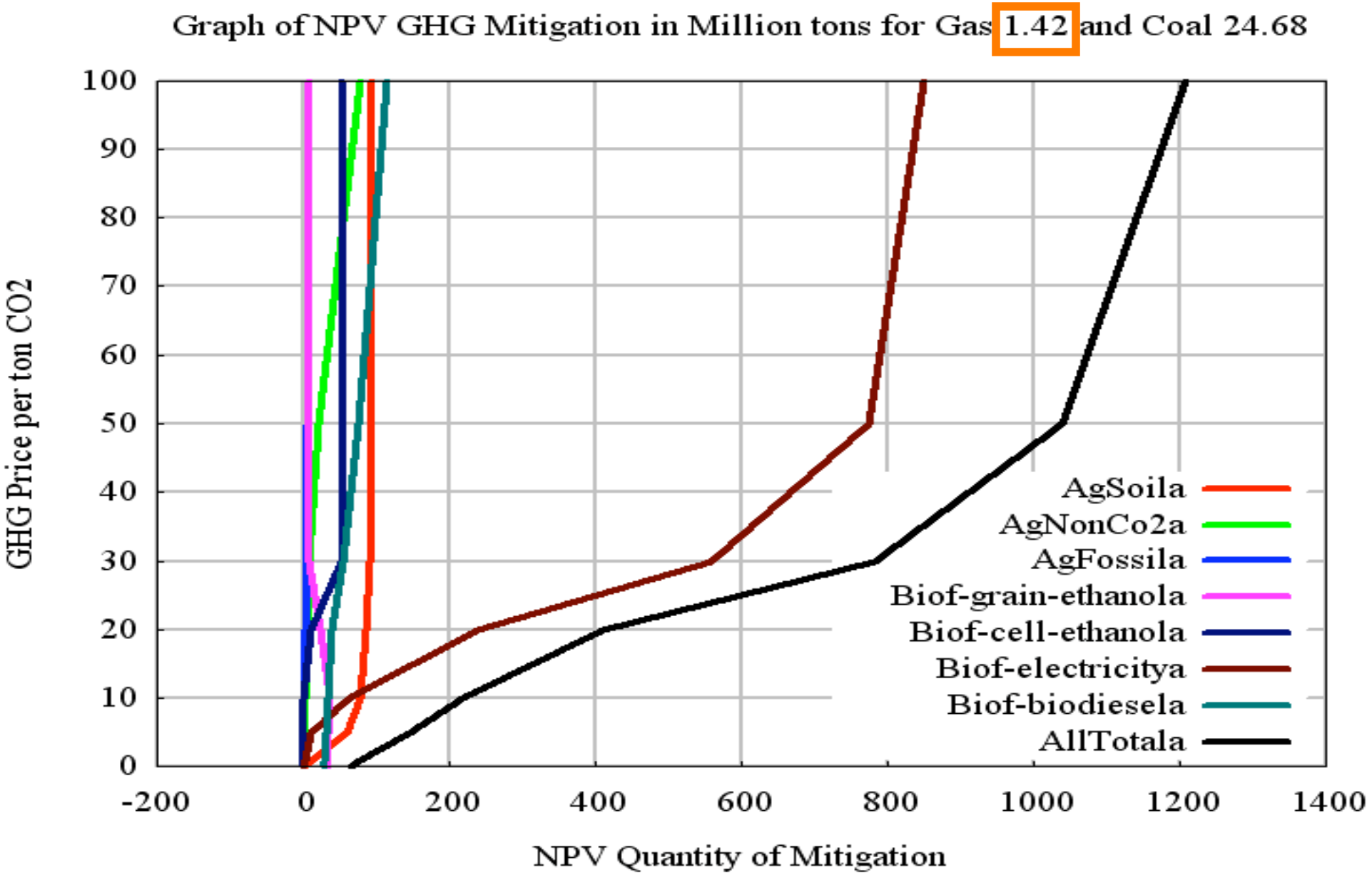
Electricity gives big numbers due to plant expansion

Other small and slowly increasing

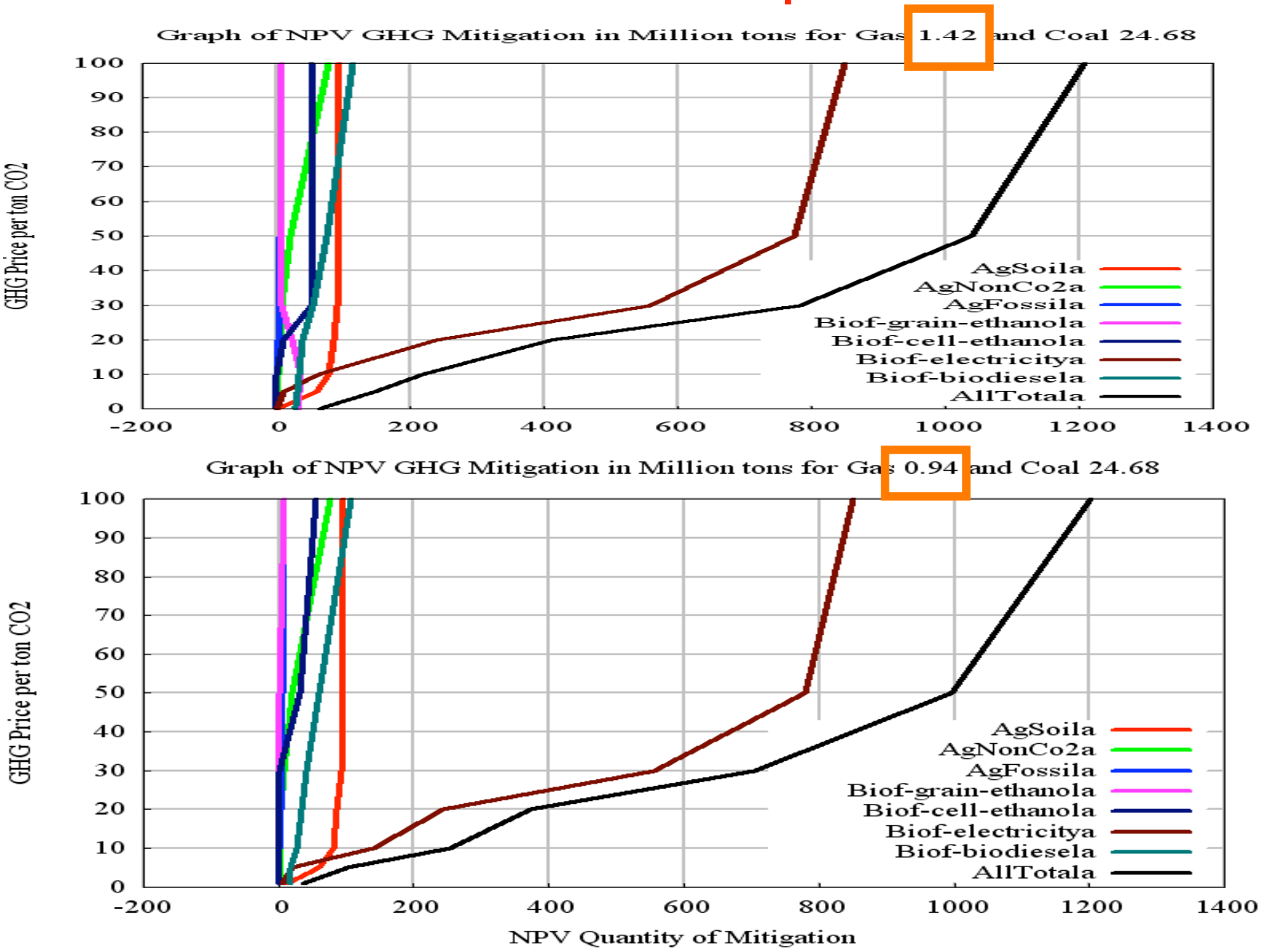
Liquid Portfolio Composition



Portfolio Composition



Portfolio Composition



Liquid Biofuel Portfolio Composition

	Gas price 0.94				Gas price 2.00			
Lower carbon dioxide price	-1	10	30	50	-1	10	30	50
Upper carbon dioxide price	10	30	50	5000	10	30	50	5000
Corn into ethanol wet milling	xx	xx	xx	xx	xx	xx	xx	xx
Corn into ethanol dry milling	xx	xx	xx	xx	xx	xx	xx	
Make wheat into ethanol				xx				xx
Make sorghum into ethanol	xx	xx	xx		xx	xx		
Sugarcane Bagasse into ethanol				xx		xx	xx	xx
Make corn residues into ethanol				xx		xx	xx	xx
Make wheat residues into ethanol								xx
Make sorghum residues into ethanol				xx				
Make rice residues into ethanol				xx				xx
Make soybean oil into biodiesel	xx	xx	xx	xx	xx	xx	xx	xx
Make corn oil into biodiesel			xx	xx	xx	xx	xx	xx

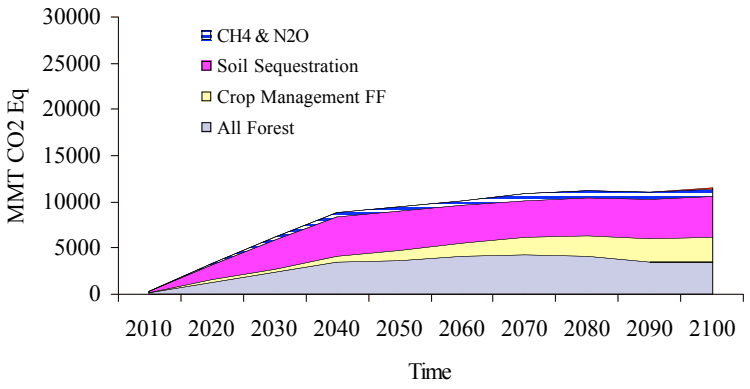
GHG offset and energy price send similar signals
Cellulosic at higher prices, switchgrass and residue

Electricity Portfolio Composition

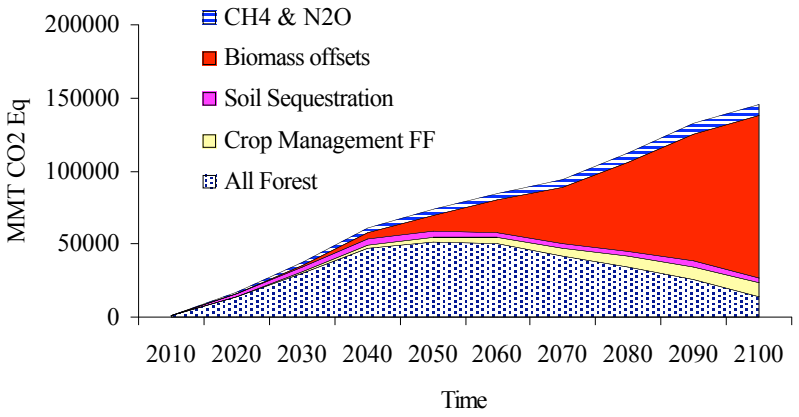
	Coal price 24.68				Coal price 49.36			
Lower carbon dioxide price	-1	10	30	50	-1	10	30	50
Upper carbon dioxide price	10	30	50	5000	10	30	50	5000
Switchgrass to electricity 5% co firing	Xx	xx	xx	xx	xx	xx	xx	xx
Make switchgrass into electricity			xx	xx			xx	xx
Make willow into electricity		xx	xx	xx		xx	xx	xx
Make lignin into electricity				xx				xx
Manure into electricity 20% co firing			xx	xx		xx	xx	xx
Sugarcane Bagasse into electricity	xx	xx	xx	xx	xx	xx	xx	xx
Corn residues to elec 20% co firing				xx				xx
Make corn residues into electricity			xx	xx		xx	xx	xx
Wheat residues elec 20% co firing			xx	xx		xx	xx	xx
Make wheat residues into electricity		xx	xx	xx		xx	xx	xx
Sorghum res, to elec. 20% co firing				xx				xx
Make sorghum residues into electricity			xx				xx	
Make barley residues into electricity		xx	xx	xx	xx	xx	xx	xx

Cofiring ratio increases with price
Residues Show at higher prices
Sugarcane bagasse at all prices

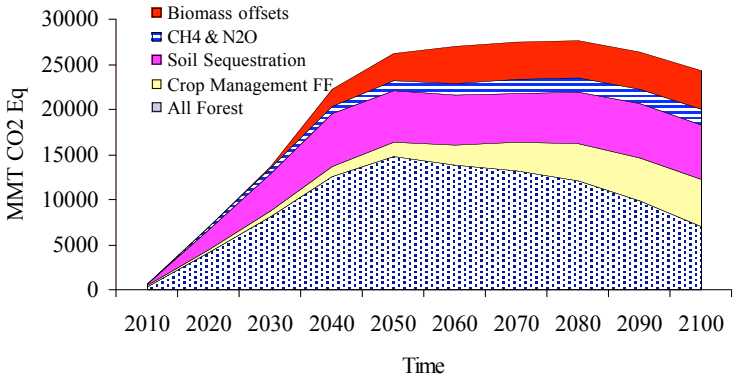
Dynamics and Saturation



Cumulative Contribution at a $5 per tonne CO2 Price



Cumulative Contribution at a $50 Price



Cumulative Contribution at a $15 Price

Note

Effects of saturation on sequestration
Growing nonco2 and biofuels

Source Lee, H.C., B.A. McCarl and D. Gillig, "The Dynamic Competitiveness of U.S. Agricultural and Forest Carbon Sequestration," 2003.

Effects on Ag sector

Conventional Production Lower by 1/6

Livestock Production Lower by 1/4

Exports lower by _

Prices higher by _

Farm incomes double

Consumers pay

Trading partners pay

Why else might the biofuels dominate Ag GHG response

Alleviates problems plaguing other agricultural ghg offsets with

- Permanence - saturation
- Additionality – already being done
- Uncertainty – delivery at processing
- Transactions cost – no agents needed
- Engineering solution – large scale control
- Problems with Leakage – CDM and palm oil

Why else might the biofuels dominate Ag response

Helps in some co benefits, causes other co costs

Much more elastic demand curve helps farm income

Negative emissions with Carbon Capture and Storage

GHGs and Money

Carbon markets may arise if we implement cap and trade

Have under Kyoto in Europe

$25-35 per metric ton CO2

Limited markets in US

$2-4 per metric ton CO2

GHGs and Money

Coal 30-86% carbon so a ton of coal emits
~ 50% carbon or 1.8 tons CO2

Emissions Cost in Europe $12.5 to $18
Cost in US $1.25 to $1.80

Coal current cost per ton $25 cost

Gasoline CO2 emissions 8.8 kg/gallon
Emiss. cost in Europe $0.22 in US $0.022

Gasoline current pre tax cost ~$2.00 per gallon

GHGs and Money

Wood 50% carbon switchgrass 44%

Offset carbon through photosynthesis and replacement of coal / gasoline

So emission offset earnings or gain advantage relative to fossil fuels

GHGs and Money

Biofuels will likely not create items sold in carbon market excepting sequestration if it ever sells

But

- **Fossil energy production or consumption will likely require emission permits raising consumer price of fossil fuel use**

- **Biofuel combustion will likely not require such permits and price will rise on BTU or other basis to price of fossil fuel**

- **Feedstock demand will rise same effect as selling offset in market**

Money to be made

Findings

- Biofuels could play important part in GHG mitigating world
- At low fuel and carbon prices opportunity cost of resources exceeds value of feedstocks generated.
- Competitiveness in GHG arena arises because biofuels continually offset fossil fuel emissions in comparison to sequestration which saturates
- Tradeoffs with food/fuel/exports if we produce biofuels
- Strong degree of farm income support, Raises Consumer Food Costs
- Can yield large volumes

Big questions

- Will society choose to reward biofuel carbon recycling?
- Will energy prices remain high in short run?
- Will ethanol and biodiesel subsidies persist?
- When will cellulosic ethanol be producible at scale?
- Can we increase biofuel feedstock yields?
- Can we increase energy recovery efficiency from biofeedstocks?
- Will we switch farm subsidies to energy or carbon subsidies?
- Will food technical progress remain high?
- Will we think about this as we plot future of energy?
- Will the science community expand the definition of biofuels away from corn ethanol?

For more information

http://agecon2.tamu.edu/people/faculty/mccarl-bruce/biomass.html