FASOM –GHG2, Stabilization Scenarios and other items

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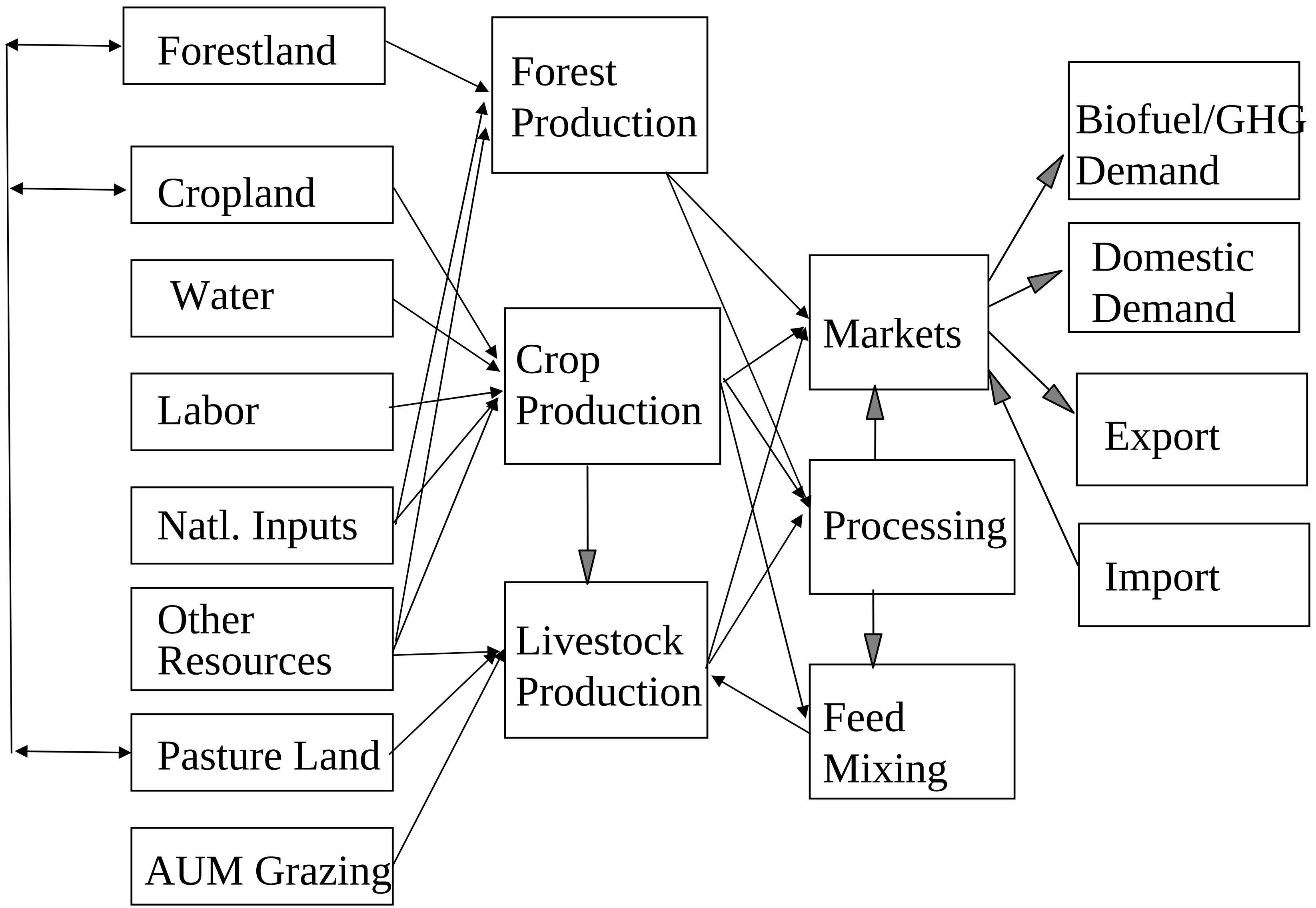
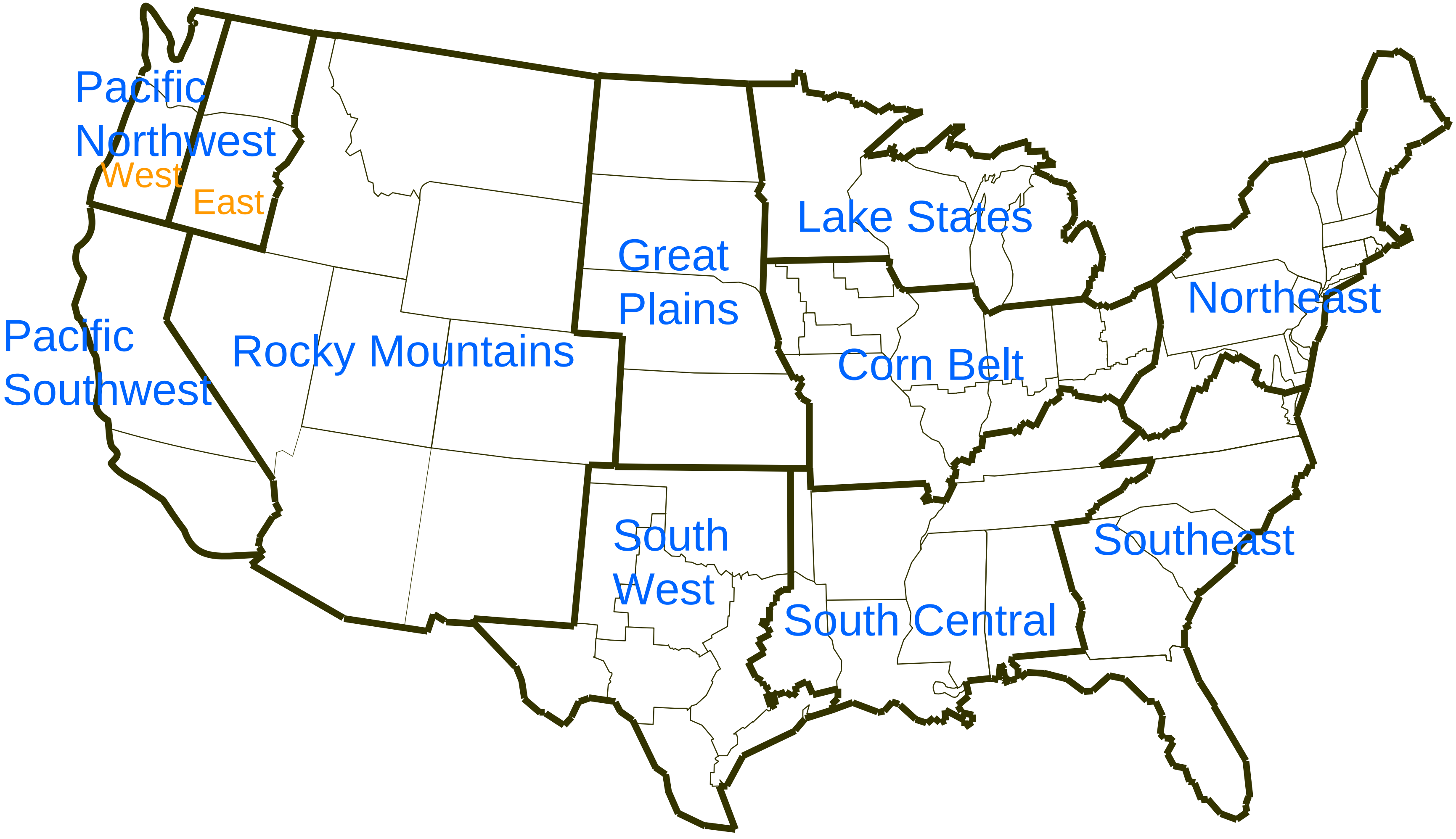
Basic Modeling -- FASOMGHG



FASOM Agricultural Regions



Foreign Regions in FASOM

FASOM has supply and demand curves for corn, 4 types of wheat, soybeans, rice and sorghum across the above regions and within 11 major US regions where the region trades the commodity. FASOM also maintains transportation costs between all regions. The model determines exports to the point where prices are in equilibrium considering transport across all markets.

Primary Commodities

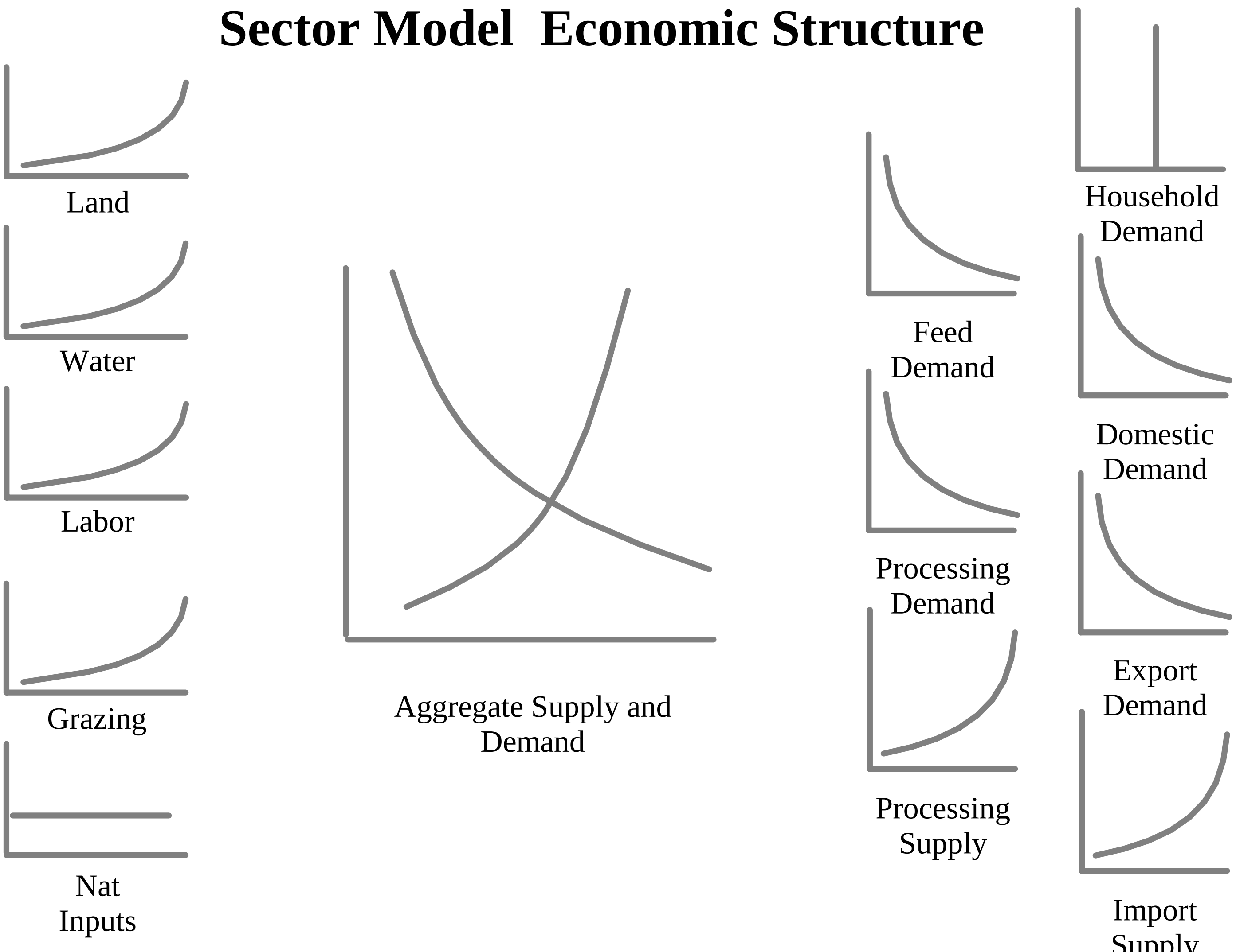
Cotton	Corn	Soybeans	Sorghum
SOFT	HRWW	DURW	HRSW
Rice	Oats	Barley	Potatoes
Silage	Hay	Alfalfa	Sugarcane
Sugarbeet	Tomatofrsh	Tomatoproc	Orangefrsh
Orangeproc	Grpfrtfrsh	Grpfrtproc	SwitchGras
HybrPoplar	Willow	BioManure	Cornres
SorgRes	RiceRes	WheatRes	OatsRes
BarleyRes			

Sheep	CowCalf	BeefFeed	Dairy
HogFarrow	FeedPig	PigFinish	OthLvstk
StockSCav	StockHCav	StockSYea	StockHYea
VealCalf	Turkeys	Broilers	Eggs
Beefcows			

Secondary Commodities

OrangeJuic	GrpfrtJuic	SoybeanMeal	SoybeanOil
HFCS	Beverages	Confection	Baking
Canning	RefSugar	GlutenMeal	GlutenFeed
DDG	CornStarch	CornOil	CornSyrup
Dextrose	FrozenPot	DriedPot	ChipPot
FedBeef	NonFedBeef	Pork	Chicken
Turkey	WoolClean	FluidMilkwhol	FluidMilkLowFat
SkimMilk	Cream	EvapCondM	NonFatDryM
Butter	AmCheese	OtCheese	CottageChe
IceCream	Bagasse	Lignin	LigninHardwood
LigninSoftwd	EdTallow	NonEdTallow	YellowGrease
CropEthanol	CellEthanol	Biodiesel	BiodieselWO
MktGasBlend	SubGasBlend	Tbtus	

Model Economic Structure



Last years work on Biofuels

- Biofuels offer a potential way of using abundant agricultural resources to help reduce dependence on fossil fuel contributing to
  - reductions in net greenhouse gas emissions
    - Carbon recycling
    - Enhanced sequestration – perennials, soils
    - Lower inputs
    - Offset by processing, production, transport
  - improved energy security

Background

- So what? Biofuels have been known to society throughout history
- Their usage has diminished over the long run (we used a lot of wood in early 1900's) and has not greatly increased in the last few years particularly in unsubsidized forms
- This is largely due to the availability of cheap fossil fuels.
- Thus for biofuels to serve significant role as GHG offset or energy security enhancement then forces will have to arise that will make them competitive.

Biofuel feedstocks

- Agricultural and forestry products:
  - Grains -Corn, Wheat, Sorghum, Rice
  - Sugar Cane
  - Timber
- Production residues:
  - Crop Residue
  - Logging Residue
  - Manure
- Processing products and by products:
  - Corn Oil
  - Rendered Animal Fat
  - Milling Residue
- Energy crops:
  - Switchgrass
  - Willow
  - Hybrid Poplar

Not doing red items today

Bio feedstocks into Energy

Bio feedstocks can be direct inputs into power plants to substitute for coal

They also can be used to produce liquid fuels such as ethanol and biodiesel

For Example

- Energy crops, residues and trees can fire or co-fire power plants
- Ethanol can be made from the cellulosic content of energy crops, residues and trees
- Grains and sugar can be processed into ethanol
- Fats and oils can be made into biodiesel

Offset Rates Computed Through Lifecycle Analysis

Net Carbon Emission Reduction (%)

Bio feedstock	Ethanol	Electricity	Biodiesel
Corn	43		11
Soybeans			96
Sorghum	45		
Barley	43		
Oats	39		
Rice	12		
Soft White Wheat	42		
Hard Red Winter Wheat	41		
Durham Wheat	39		
Hard Red Spring Wheat	42		
Sugar	28		
Switchgrass	81	87	
Hybrid Poplar	72	89	
Willow	74	94	
Softwood Log Residue	68	91	
Hardwood Log Residue	69	91	
Bagasse	86	95	
Corn Residue	84	91	
Wheat Residue	79	88	
Sorghum Residue	73	76	
Barley Residue	56	64	
Rice Residue	55	62	
Softwood Mill Residue	76	95	
Hardwood Mill Residue	76	95	
Manure		91	

Electricity offsets higher when cofired due to Efficiency and less hauling

Ethanol offsets are in comparison to gasoline

Power plants offsets are in comparison to coal.

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
Biofuel 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 (not today)	Sequestration	X		
Existing timberland Management	Sequestration	X		
Deforestation	Emission	X		

Stabilization Scenarios

Price from steve rose per ton C

	MESSAGE-EMF21-3.0 (B2)	GRAPE-EMF21-4.5
2000	0	0
2005	17.54	0.8
2010	35.08	1.6
2015	46.335	2.35
2020	57.59	3.1
2025	75.355	4.55
2030	93.12	6
2035	123.385	9.15
2040	153.65	12.3
2045	200.625	18.4
2050	247.6	24.5
2055	324.935	36.55
2060	402.27	48.6
2065	528.335	73.05
2070	654.4	97.5
2075	858.68	213.1
2080	1062.96	328.7
2085	1402.065	477.95
2090	1741.17	627.2
2095	2279.015	771.65
2100	2816.86	916.1

Stabilization Scenarios

GRAPE-EMF21-4.5	2010	2020	2030	2040	2050
AgSoil	-2	-57	-6	-125	88
AgFuel	0	0	0	1	4
AgFertil	0	0	1	1	3
Biof-biodiesel	0	0	0	-6	0
Biof-grain-ethanol	0	1	0	9	-3
Biof-cell-ethanol	0	-1	-1	-15	-196
Biof-electricity	-10	-107	-1	-328	-804
ManureEmit	0	0	0	0	0
Enteric	0	0	0	0	0
TotalAG	-14	-165	-7	-463	-910
MESSAGE					
AgSoil	4	-309	22	-346	217
AgFuel	-5	-10	-12	11	25
AgFertil	9	37	50	64	111
Biof-biodiesel	0	2	2	40	9
Biof-grain-ethanol	0	14	7	-51	-187
Biof-cell-ethanol	1	-23	-8	84	-71
Biof-electricity	-238	-1388	-1352	-2829	-3888
ManureEmit	-3	-4	-11	-56	-60
Enteric	-22	-17	-22	-95	-126
TotalAG	-257	-1705	-1330	-3178	-3969

All figures annual increment in million tons CO2 Eq

Stabilization Scenarios

MESSAGE	2010	2020	2030	2040	2050
AgSoil	4	-309	22	-346	217
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Strategies Used Stabilization Scenarios

Renewable fuel scenario	base	GRAPE-	MESSAGE
1000s of acres of rice	3164	3139	2042
Beef herd	45977	45552	39025
Total dairy	7814	7813	6979
Total hogs finished	84586	85216	93828
Total Broiler	9448951	9459929	9169046
Total Egg	371818	372301	368198
Dairy under manure mgt	28494	41829	40240
Hogs under manure mgt	142387	143440	371767
Corn % fertilizer use	100	92	87
Wheat % N fertilizer use	100	98	60
Corn acres	69049	69542	65206
Wheat acres	44585	44886	58863

Annuity distortions a problem

Strategies Used Stabilization Scenarios

Renewable fuel scenario	base	GRAPE	MESSAGE
Conventional tillage	187774	183688	121434
Conservation tillage	48678	61516	109613
No till tillage	47439	39875	78349
Acres cropped	2838913	2850789	3093959
Acres energy crops	406	408	33689
Acres harvested residues	20976	24582	67418
Acres produced under irrigation	243790	244106	271455
Amount of Diesel used	2193194	2201282	2113433
Amount of Gasoline used	270011	266393	244955

Annuity distortions a problem

Strategies Used Stabilization Scenarios

Renewable fuel scenario	base	GRAPE-EMF21-4.5	MESSAGE-EMF21-3
Crop Grain and Sugar Ethanol Prod	8602	8836	10435
Cellulosic Ethanol production	6478	8875	7738
Biodiesel production	349	376	328
Ethanol from corn	7677	7907	6256
Ethanol from wheat sorghum barley oats	925	928	4179
Ethanol from crop residue	6108	8489	7401
Biopower 1000 Tbtus (7 =100 megawatt plant)		1	12
1000 Tbtus from crop residue			5
1000 Tbtus from energy crops			6
1000 Tbtus from ethanol byproduct lignin		1	
Plants with 5 percent cofire	229	230	12496
Plants with 10 percent cofire			28
Plants with 15 percent cofire			150
Plants with 20 percent cofire		125	2120
Plants whole fueled with biomass	94	148	681

Annuity distortions a problem

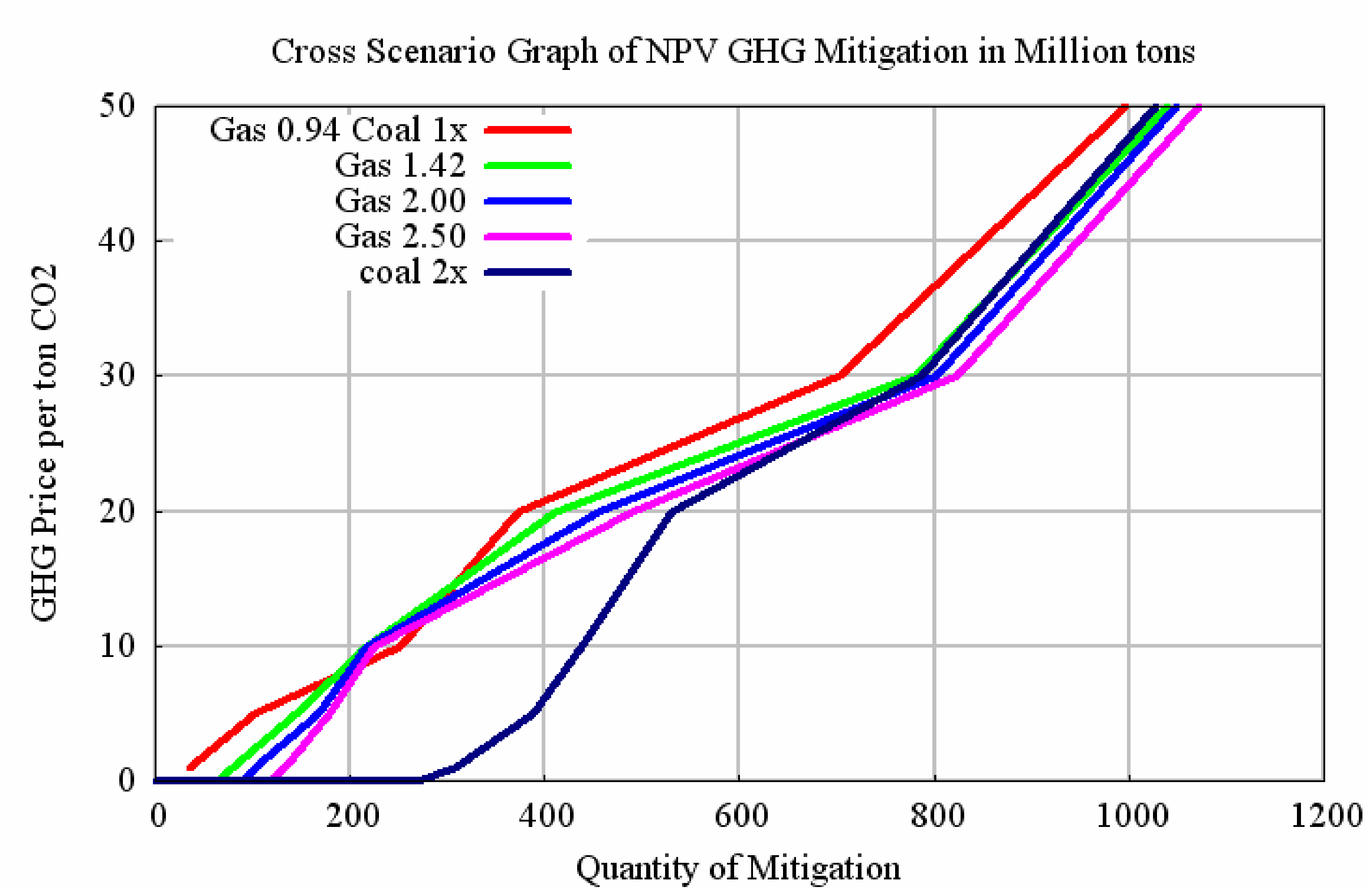
Finally Biofuel Economics

- **Has historically not been an economic proposition but at today's energy prices it looks better.**
- **In U.S. ethanol subsidies used to amount to over 50% of product sale price.**
- **Bolstered by sugar program**
- **Today payoff for subsidized plants (Corn to ethanol) is 1-2 years.**
- **Production capacity soon 4 x greater than 2001**
- **Substantial Capital/price risk in some segments with subsidy key part**

What will make Biofuels economic

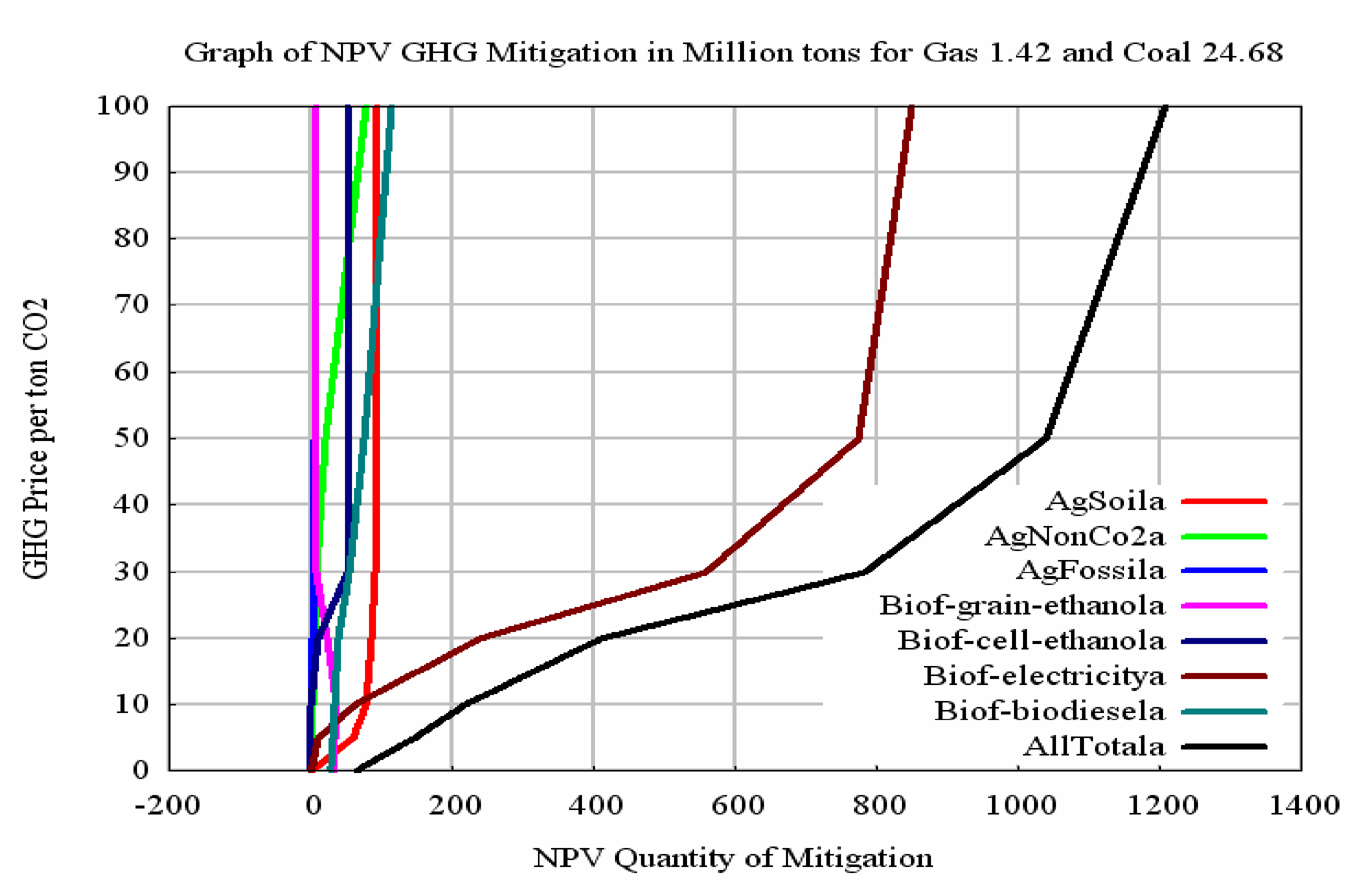
- Rising energy prices
  - Scarcity and demand growth
  - Energy Security
  - Trade disruption
- Rising GHG prices
- Lower costs of delivered feedstock because of higher yields, improved production practices, lower transport needs
- Improved energy recovery efficiency

GHG CO2 Eq Offset Volume



Note offsets increase with energy price and carbon dioxide price
US potential Kyoto about 2200
High Carbon prices win

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

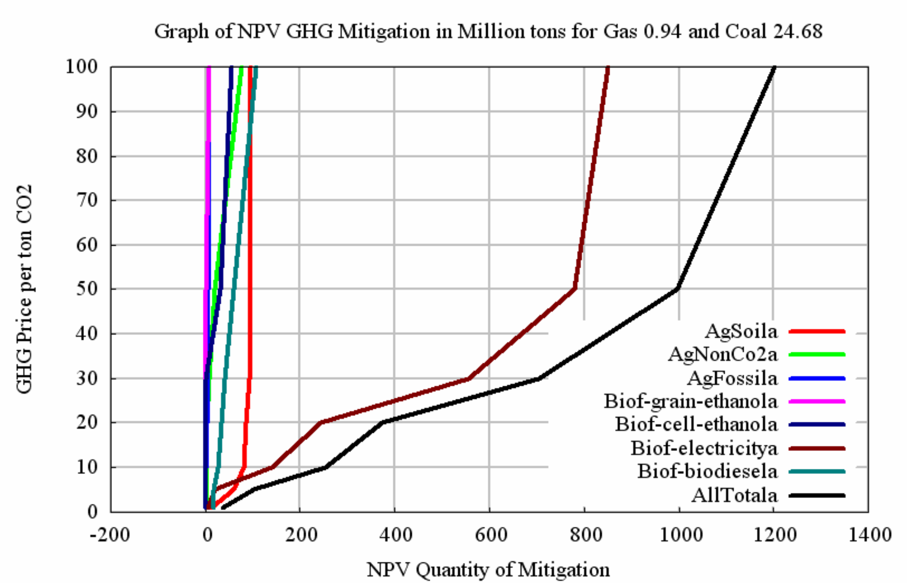
Lower per acre rates than higher cost alternatives

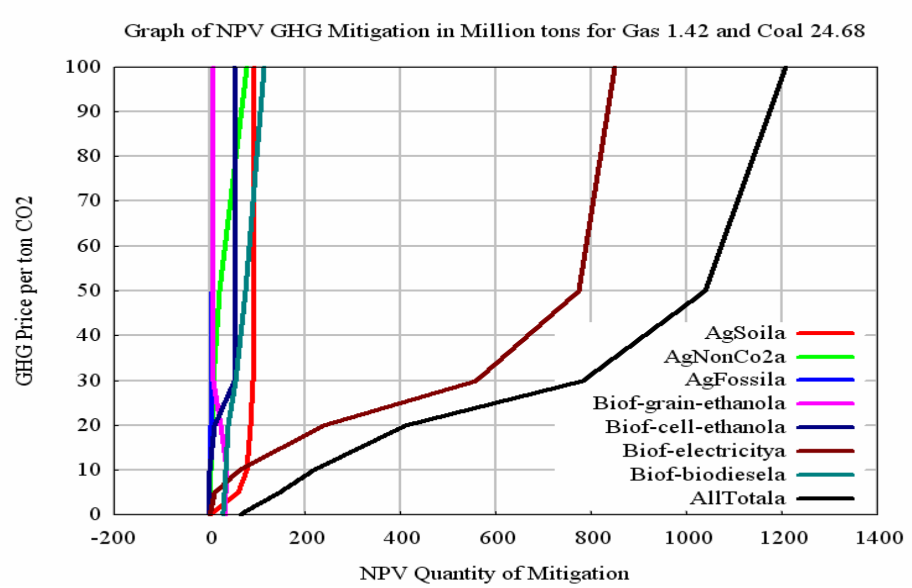
Biofuel takes higher price but takes off

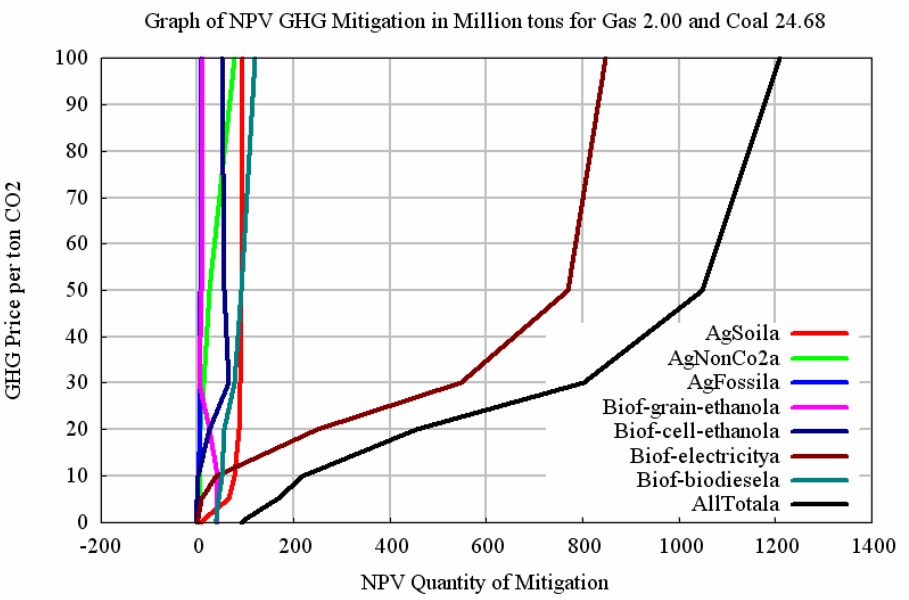
Electricity gives big numbers due to plant expansion

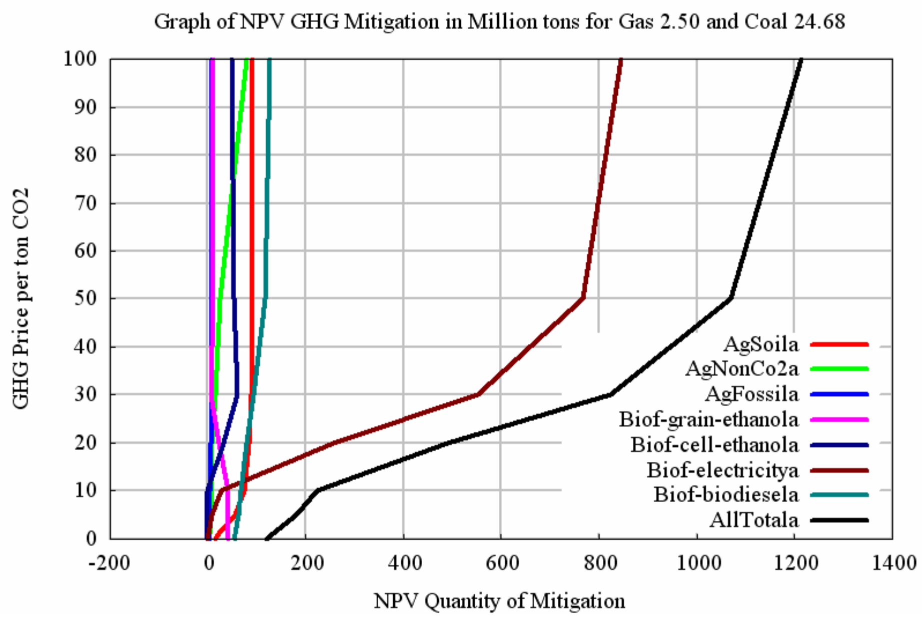
Other small and slowly increasing

Portfolio Composition

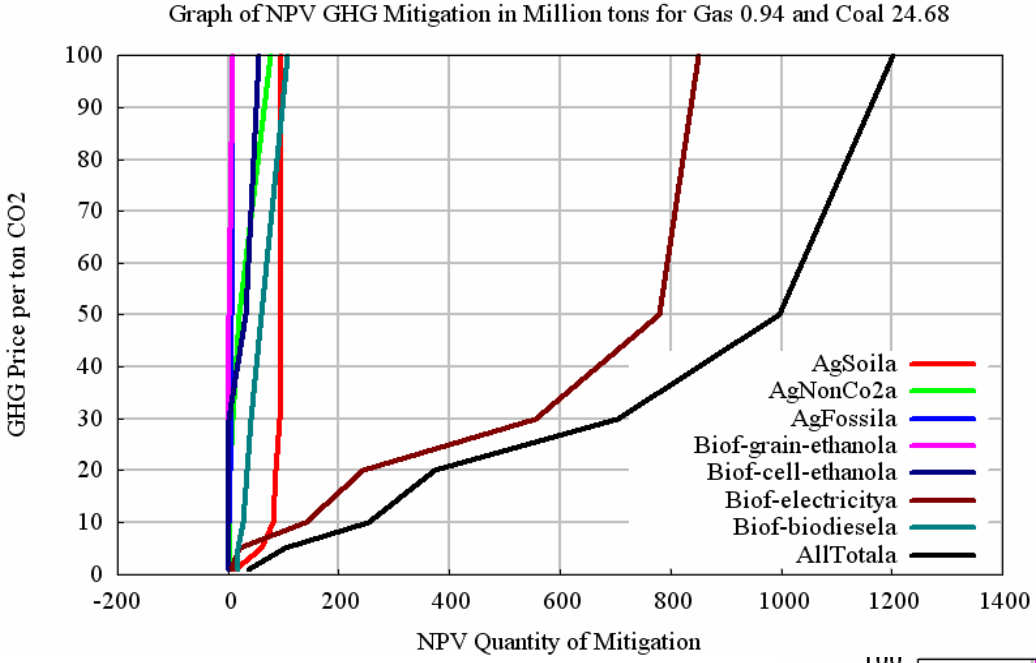


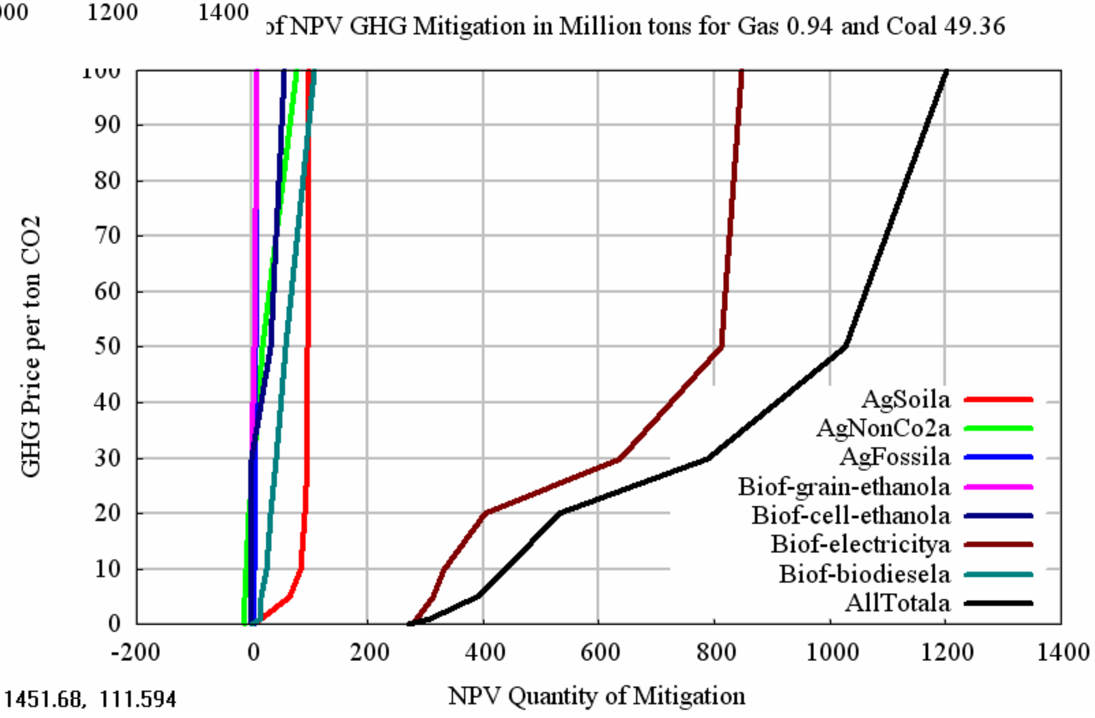




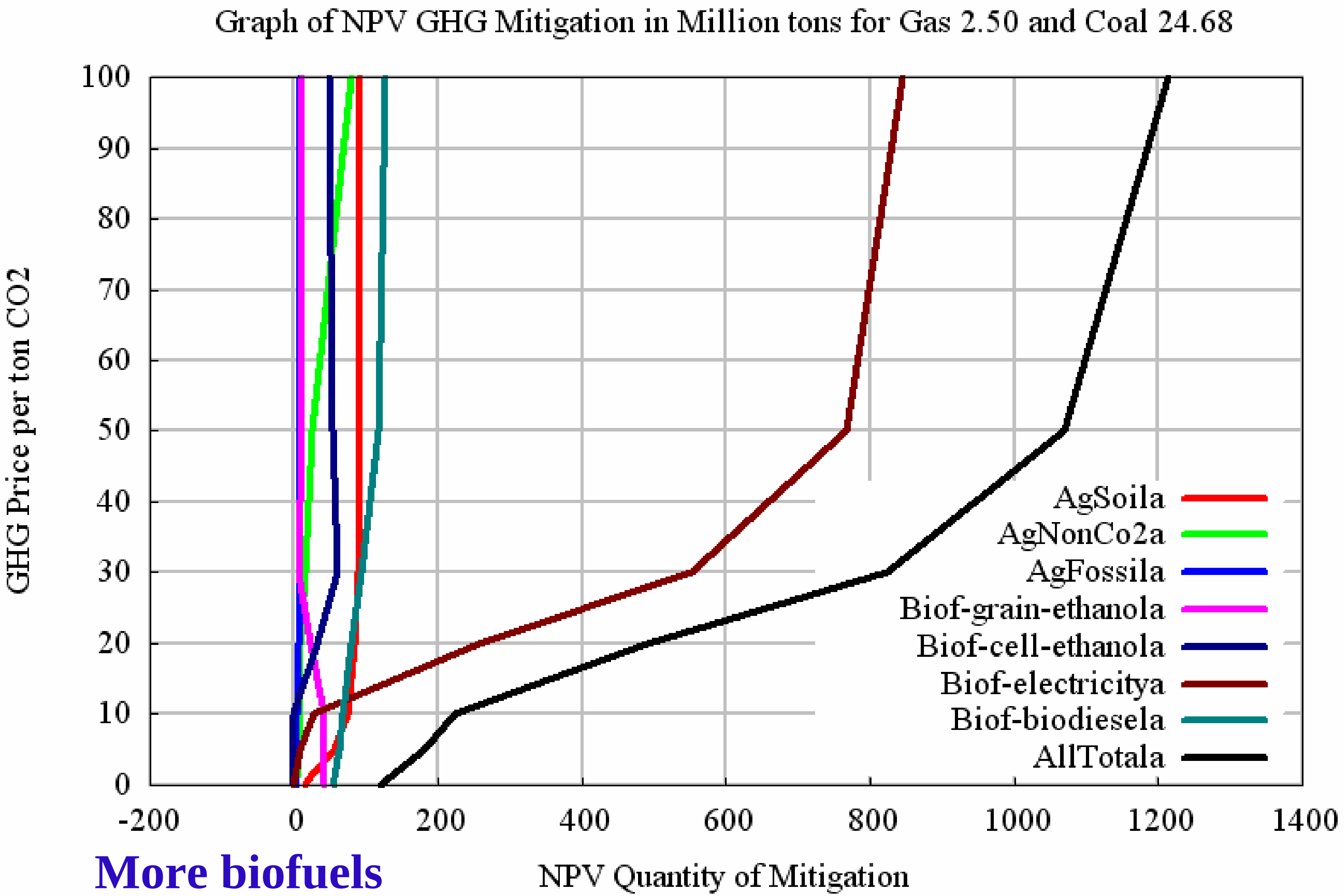


Portfolio Composition



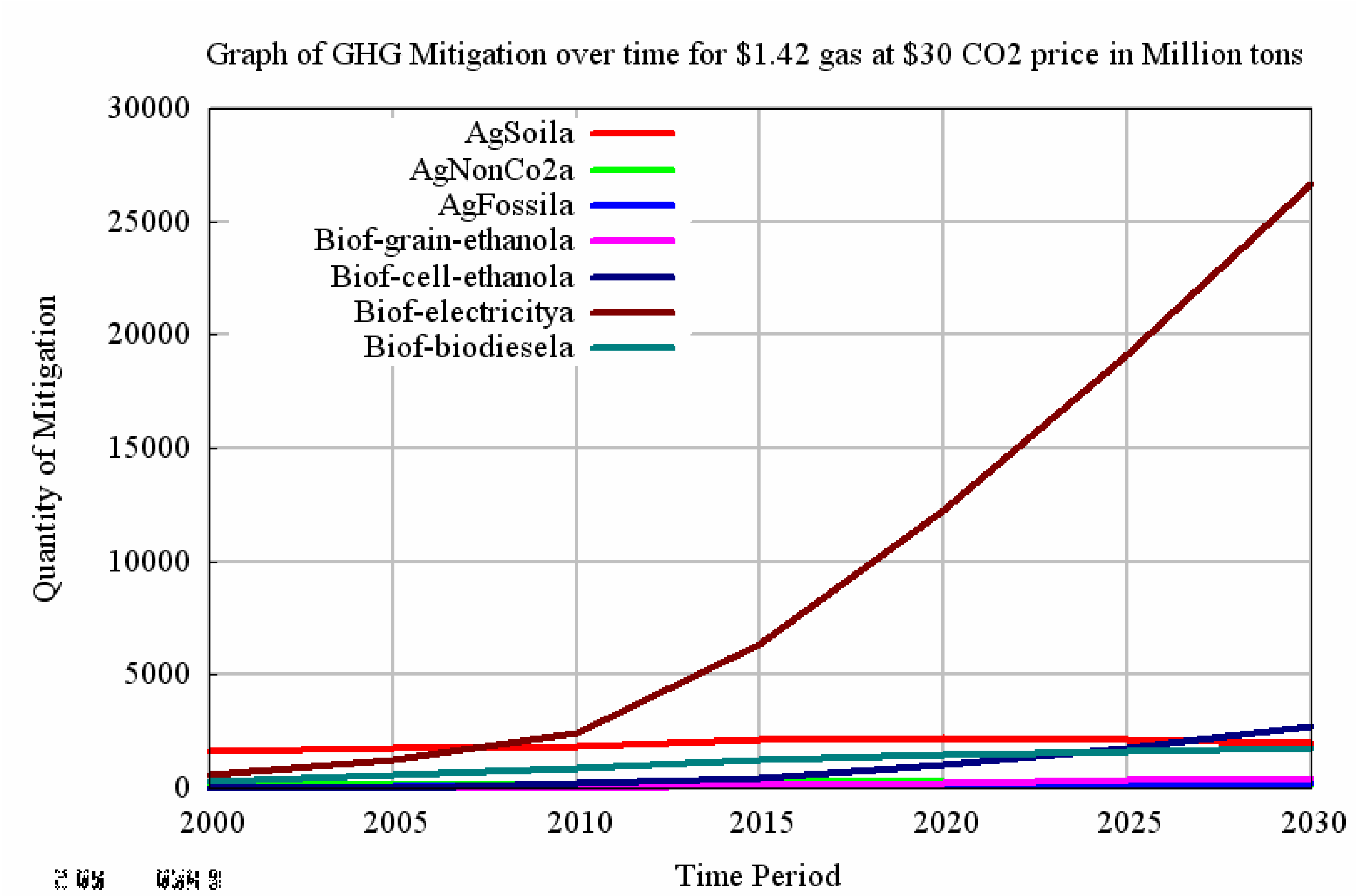


Expensive $2.50 gas Portfolio Composition



More biofuels
In at zero carbon price

Dynamic Portfolio Composition



More biofuels

In at zero carbon price

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 through wet milling	xx	xx	xx	xx	xx	xx	xx	xx
Corn into ethanol through dry milling	xx	xx	xx	xx	xx	xx	xx	
Make wheat into ethanol				xx				xx
Make sorghum into ethanol	xx	xx	xx		xx	xx		
Make 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

Corn at all prices but not unsubsidized

Cellulosic at higher prices, switchgrass and residue

Lignin by product into electricity

Biofuel 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 into 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
Make manure into electricity 20% co firing			xx	xx		xx	xx	xx
Make sugarcane Bagasse into electricity	xx	xx	xx	xx	xx	xx	xx	xx
corn residues into electricity 20% co firing				xx				xx
Make corn residues into electricity			xx	xx		xx	xx	xx
Wheat residues o electricity 20% co firing			xx	xx		xx	xx	xx
Make wheat residues into electricity		xx	xx	xx		xx	xx	xx
Sorghum residues 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

US and Rest of World Comparison of Annualized Gain in Welfare in Billion 2000$

	Gasoline Price in $/Gallon	Coal Price in $/ Ton	0	1	5	10	20	30	50	100
United States	0.94	24.68		0.15	1.56	14.05	45.92	138.90	347.90	845.02
	1.42	24.68	1.53	2.10	5.28	13.01	52.80	157.45	364.05	851.62
	2.00	24.68	4.78	5.59	9.16	16.11	61.74	165.58	371.82	856.73
	2.50	24.68	7.79	8.72	12.83	19.49	69.66	173.96	382.16	862.86
	0.96	49.36	4.91	7.37	18.64	34.96	76.21	166.03	368.73	852.95
Rest of the World	0.94	24.68		0.01	0.06	-0.72	-1.66	-2.30	-2.71	-3.36
	1.42	24.68	-1.23	-1.23	-1.41	-1.81	-2.83	-2.84	-3.16	-3.55
	2.00	24.68	-1.99	-2.03	-2.17	-2.45	-3.14	-3.24	-3.67	-3.70
	2.50	24.68	-2.43	-2.50	-2.63	-2.79	-3.41	-3.70	-3.84	-3.89
	0.96	49.36	-2.18	-2.23	-2.44	-2.53	-2.75	-2.39	-2.81	-3.57
Total Globally	0.94	24.68		0.16	1.62	13.33	44.26	136.60	345.19	841.66
	1.42	24.68	0.30	0.87	3.87	11.20	49.98	154.61	360.88	848.07
	2.00	24.68	2.79	3.57	6.98	13.67	58.59	162.34	368.15	853.03
	2.50	24.68	5.37	6.22	10.20	16.70	66.25	170.26	378.32	858.97
	0.96	49.36	2.72	5.14	16.19	32.43	73.46	163.64	365.93	849.38

Production Exports and Prices

	Gasoline	Coal	0	1	5	10	20	30	50	100
Conventional Farm Production	0.94	24.68	100.0	99.9	99.4	98.2	95.9	94.3	91.2	83.6
	1.42	24.68	100.0	99.7	99.2	98.6	96.0	94.8	91.8	83.7
	2.00	24.68	100.1	100.0	99.5	98.9	96.5	94.8	91.8	83.9
	2.50	24.68	100.3	100.1	99.7	99.3	96.8	94.9	92.3	84.2
	0.96	49.36	98.2	98.0	97.1	96.3	95.1	94.2	91.3	83.7
Livestock Production	0.94	24.68	100.0	99.8	99.2	97.8	94.9	92.9	88.6	77.3
	1.42	24.68	99.5	99.3	98.6	97.7	94.8	93.4	89.1	77.2
	2.00	24.68	99.7	99.5	98.8	98.1	95.6	93.6	88.9	77.3
	2.50	24.68	99.9	99.6	99.0	98.6	95.8	93.5	89.6	77.5
	0.96	49.36	98.6	98.2	97.1	96.1	94.3	92.9	88.6	77.2
Quantity Exported	0.94	24.68	100.0	99.9	99.4	93.8	86.2	80.9	71.4	47.4
	1.42	24.68	91.0	90.6	88.5	86.2	78.9	74.0	65.9	45.1
	2.00	24.68	84.4	84.1	81.8	78.3	72.2	69.7	61.3	43.7
	2.50	24.68	77.7	77.1	75.3	72.8	68.6	64.5	48.9	42.5
	0.96	49.36	86.1	86.0	84.8	83.6	79.5	79.6	70.7	46.4
Agricultural Commodity Price	0.94	24.68	100.0	100.0	99.9	104.2	112.3	116.8	121.5	141.2
	1.42	24.68	108.2	108.3	109.1	112.0	121.3	121.9	126.9	145.1
	2.00	24.68	112.6	112.8	113.9	116.4	125.1	126.6	132.0	149.2
	2.50	24.68	116.1	116.5	117.9	120.1	128.8	132.0	135.4	153.3
	0.96	49.36	115.1	115.5	117.6	118.8	121.4	117.0	123.2	142.8

Biofuels Conclusions

- Biofuels could play an important part in a GHGE mitigating world if price was above $5 per ton of carbon dioxide or if energy price is higher.
- At low 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 changing tillage which saturates
- Biofuels may also yield other ancillary benefits.
- Big questions: Will society choose to reward their carbon recycling characteristics and Will energy prices remain high?

Conclusions

Electricity dominates for GHG offset

Biodiesel is small

Cellulosic takes higher carbon prices

Cogeneration ethanol/crop lignin

Limitations

- No forest as of now
- Power plant market penetration limitation
- No biofeedstock technology experiments

All of above to be fixed soon

- Host of other sins – for example
  - foresight,
  - US only

For more information

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