# The economics of biofuel

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# Why Biofuel ?

- Increase in demand for fuel
  - 18 cars/1000 people in China vs. 800 in US
  - Tata's Nano car
- Constrained supply of oil
  - Tar sands, CTLs have their own problem
- Concern about climate change
- Limited capacity to induce conservation (minimal support for carbon tax, CAFÉ and LCFS have limited capacity for change)
- Biofuel are not new- take advantage of human skill -farming

# Various perspective on Economics of Biofuel

- Micro vs.. Macro
  - Micro -
    - economics on farm and at plant
  - Macro-
    - Impacts on markets economies and distribution of resources among groups and nation
- Private vs. public
  - Private consider choices of agents subject to constraints
  - Public looks at social costs and considers what to do about them

# The economics of biofuel on the farm

- Farmers will sell  a food crop to biofuel processor if

  Earning from biofuel plus residue (DDGs)> earning from food adjusting to transport and other costs
- In case of a biofuel that requires extra investment ( second generation) - farmers may need a longer term contract
- Higher price of energy and lower price of food will increase supply of biofuel
  - Subsidy to processor will increase willingness of farmer to commit to biofuels
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# More Biofuels on the farm

- Early results
  - Ethanol from Corn profitable at $60/BL, sugarcane at $30/BL -cheap and Clean
  - Cellulosic sources can reduce land use per energy unit of between 50% to 80%, increase carbon sequestration
  - Sweet sorghum, Jatropha has potential in dryer regions
    - Still will require water and other resources
    - May take over higher quality land - yet increase well being
  - Heterogeneity matters - need to evaluate profitability are different at different location
    - Sugar beats and wheat can be profitable under some scenarios

# Table 1.1: Production costs for biodiesel and ethanol from different feedstocks, main producing countries, 2004

| Country: | EU | | | EU | | | USA | | | EU | | | Brazil | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Biofuel: | Biodiesel | | | Ethanol | | | Ethanol | | | Ethanol | | | Ethanol | | |
| Feedstock: | Vegetable oil | | | Wheat | | | Maize | | | Sugar beet | | | Sugar cane | | |
| | Quant. | LC/t | USD/t | Quant. | LC/t | USD/t | Quant. | LC/t | USD/t | Quant. | LC/t | USD/t | Quant. | LC/t | USD/t |
| Feedstock use, t | 1.06 | | | 3.49 | | | 3.20 | | | 12.90 | | | 14.87 | | |
| Feedstock price | | 463.16 | 573.40 | | 103.73 | 128.41 | | 76.57 | 76.57 | | 23.87 | 29.55 | | 32.75 | 10.95 |
| Feedstock costs | | **490.95** | **607.80** | | **362.11** | **448.30** | | **244.66** | **244.66** | | **307.82** | **381.08** | | **486.98** | **162.80** |
| Processing costs excl. energy | | **69.29** | **85.78** | | **347.99** | **430.82** | | **130.18** | **130.18** | | **288.96** | **357.74** | | **339.49** | **113.50** |
| Energy use: methanol, kg | 145.33 | | | | | | | | | | | | | | |
| Energy: methanol, price per kg | | 0.23 | 0.28 | | | | | | | | | | | | |
| Energy use: heat, GJ | | | | 13.90 | | | 16.43 | | | 13.90 | | | | | |
| Energy: heat, price per GJ | | | | | 3.46 | 4.29 | | 4.29 | 4.29 | | 3.46 | 4.29 | | | |
| Energy use: electricity, kWh | 315.94 | | | 353.85 | | | 303.30 | | | 353.85 | | | | | |
| Energy: electricity, price per kWh | | 0.031 | 0.039 | | 0.031 | 0.039 | | 0.031 | 0.031 | | 0.031 | 0.039 | | | |
| Total energy costs | | **43.10** | **53.36** | | **59.18** | **73.27** | | **79.86** | **79.86** | | **59.18** | **73.27** | | | |
| Gross production costs | | **603.34** | **746.95** | | **769.28** | **952.39** | | **454.71** | **454.71** | | **655.96** | **812.09** | | **826.47** | **276.30** |
| Energy feed by-product; t cg-eq. | | | | 1.63 | | | 0.80 | | | 0.75 | | | | | |
| Domestic price coarse grains | | | | | 112.96 | 139.85 | | 76.57 | 76.57 | | 112.96 | 139.85 | | | |
| Protein feed by-product; t om-eq. | | | | | | | 0.16 | | | | | | | | |
| Domestic price oil meals | | | | | | | | 178.50 | 178.50 | | | | | | |
| Other by-product credit (glycerin) | | 50.00 | 61.90 | | | | | | | | | | | | |
| Total by-product credit | | **50.00** | **61.90** | | **183.90** | **227.67** | | **89.82** | **89.82** | | **84.72** | **104.88** | | **0.00** | **0.00** |
| Net production costs | | **553.34** | **685.05** | | **585.38** | **724.72** | | **364.89** | **364.89** | | **571.24** | **707.21** | | **826.47** | **276.30** |
| Net costs, per litre of fuel | | ***0.438*** | ***0.542*** | | ***0.463*** | ***0.573*** | | ***0.289*** | ***0.289*** | | ***0.452*** | ***0.560*** | | ***0.654*** | ***0.219*** |
| Net costs, per litre GE | | ***0.395*** | ***0.489*** | | ***0.702*** | ***0.869*** | | ***0.437*** | ***0.437*** | | ***0.685*** | ***0.848*** | | ***0.991*** | ***0.331*** |

Note: Cost calculations for combinations of countries and feedstock commodities other than those shown in this table which are used in the cost comparison are based on the technical coefficients used in this table, whereas domestic commodity prices and regional shares of energy sources in the generation of electricity cause biofuel production costs to differ across countries. Given the implicit assumption of equal technologies and technical coefficients across countries, production cost figures used in the report for country/commodity combinations are indicative only and might differ from specific studies on biofuel production in these countries once these become available.

*Source:* OECD Secretariat based on data provided in Smeets *et al.* (2005), Aglink database

# Considering the environment

- If processors have to meet higher environmental standard it will reduce the amount paid for biofuel
- Payment for environmental contributions at the farm level ( carbon sequestration, residue reduction) is likely to  affect crop and technology choices- and the geographic distribution of biofuel crops
- But whatever we do- productivity matters.
  - Except of sugar cane, sweet sorghum, and some oil crops the first generation of biofuels have limited capacity to address climate change concerns-you will need to be able to process celluloids

## Productivity matters

| CROP | Harvest-able Biomass (tons/ acre) | Ethanol( gal/t) | Million acres needed for 35 billion gallons of ethanol | % 2006 harvested US cropland[5] |
|---|---|---|---|---|
| Corn grain[1] | 4 | 500 | 70 | 25.3 |
| Corn stover[2] | 3 | 300 | 105 | 38.5 |
| **Corn Total** | **7** | **800** | **40** | **15.3** |
| **Prairie** | **2** | **200** | **210** | **75.1** |
| **Switch-grass** | **6** | **600** | **60** | **20.7** |
| **Miscanthus** | **17** | **1700** | **18** | **5.8** |

Source:Steve Long

# Potential of biofules

| Crop | Average yield (tons/hec) | Global acreage (mil. hec) | Global production (mil tons) | Conversion Efficiency Lit/ton | Land intensity (lit/hec) | Max. fuel (billion litres) | Gasoline equivalent (billion lit) | % annual global gasoline |
|---|---|---|---|---|---|---|---|---|
| Sugarcane | 65 | 20 | 1300 | 70 | 4550 | 91 | 61 | 4% |
| Corn | 49 | 145 | 711 | 402 | 1971 | 286 | 191 | 12% |
| Wheat | 28 | 215 | 602 | 340 | 952 | 205 | 137 | 9% |
| Sorghum | 13 | 45 | 59 | 60 | 78 | 4 | 2 | 0% |
| Sugarbeet | 46 | 54 | 248 | 110 | 5060 | 27 | 18 | 1% |
| Cassava | 115 | 19 | 219 | 180 | 2070 | 39 | 26 | 2% |
| Waste crops | - | - | 74 | 664 | - | 491 | 33 | 2% |
| Crop residues | - | - | 1500 | 295 | - | 442 | 296 | 19% |
| **Total** | | **449** | | | | **1143** | **766** | **50%** |

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|---|---|---|---|---|---|---|---|---|
| Switchgrass | 10 | 100 | 1000 | 380 | 5200 | 520 | 348 | 23% |
| Miscanthus | 22 | 100 | 2200 | 380 | 11440 | 1144 | 766 | 50% |
| **Total** | | **719** | | | | **1664** | **1115** | **73%** |

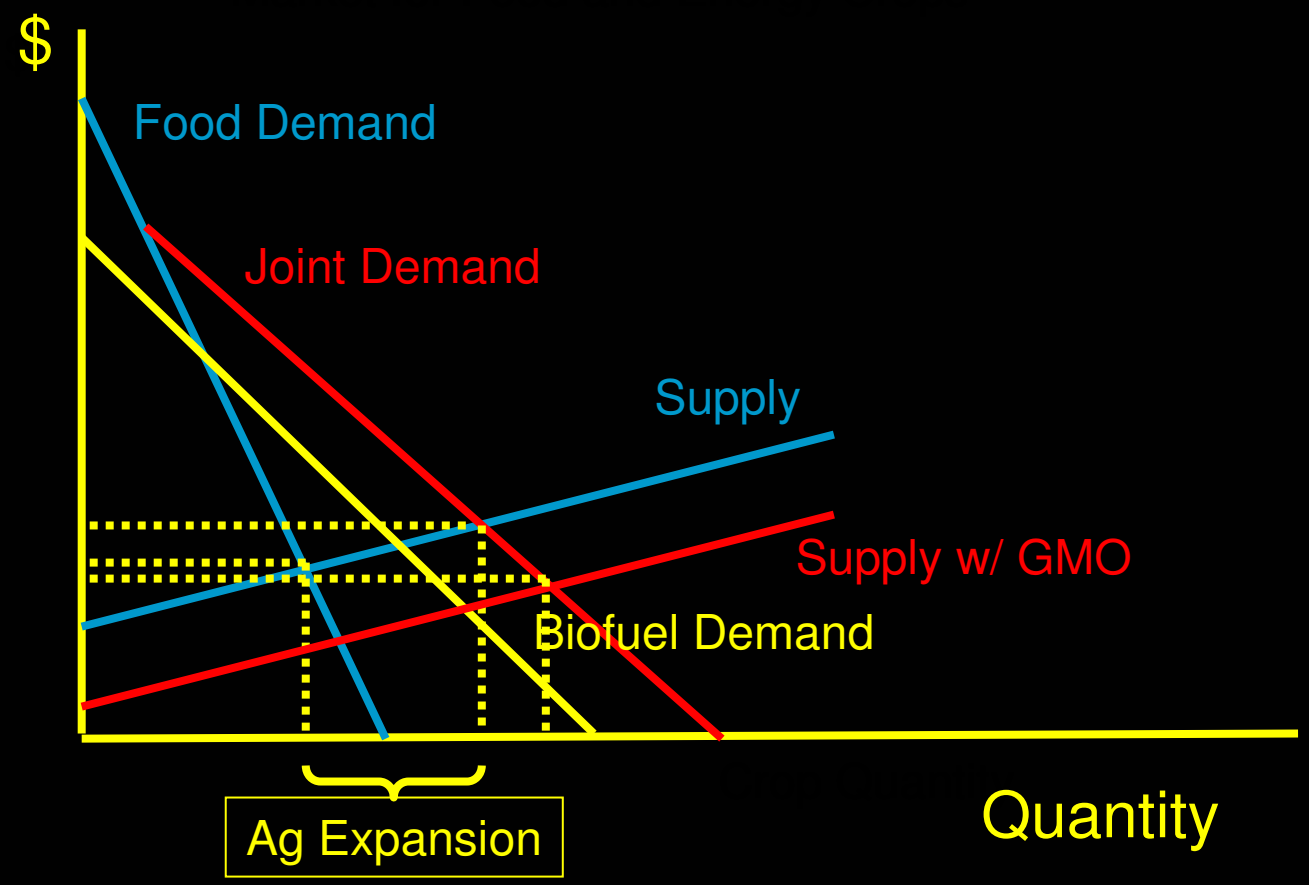
# The processor's perspective

- Investment in a processing plant is made when price of biofuel plus the subsidy will be sufficient to compete for corn and cover expense.
  - The subsidy reduces the threshold price for adoption.
  - Location matters for subsidies, costs of transportation and  energy for processing
  - Clean fuel upper bound (limiting GHG/gallon fuel)will make some processing un profitable but lead to creative solution ( biofuel and wind- especially if limits are company wide)

# Adoption of biofuels: a 4 step dance

- Consumers – will adopt if better deal than gasoline
  - ethanol has 2/3 of energy,but higher octane, may need to be cheaper than gasoline with new cars/modifications for new fuels
- Fuel seller – will consider if there is demand and supply
  - need to invest in special pumps and storage
- Processor - considers demand and the cost of processing facilities
  - How much can they gain from the co-products (DDGs)
- Farmer - consider whether biofuel will be more profitable than corn
- Coordination essential assured buyers and sellers
  - Contracts insurance arrangement will emerge
- Different biofuels in different locations depending on infrastructure institutions and climate

# Biofuel and the market



# The basic economics of biofuel

Introduction of biofuels

- Increases food prices & Reduces food availability
- These can be countered by
  - increased productivity
  - Second generation biofuels
  - Biotech
- The demand for BF is kinked-affected by
  - Mandates and ag policies
  - energy content differences between ethanol and Gasoline
- But the basic issues are meeting growing demand and addressing environmental concerns

# Who gains and who loses from biofuel in US (EARLY ESTIMATES 2006- needs improvement)

*Corn producers and gasoline consumers benefited; food consumers,oil producers and tax payers lost*

| | |
|---|---|
| Additional profit to US corn producers | $ 8.6 billion |
| Net savings to gasoline Consumers (US + ROW) | $ 41.1 billion |
| Extra cost to US corn consumers | $ 2.5 Billion |
| Corn Consumers ROW | $12 Billion |
| Taxpayer cost of ethanol tax credit + other subsidies | $6 billion |

Gain reflect reduction In fuel prices because of increased supply

# Biofuel energy and the environment: Effects of high energy prices biofuel on water

- High energy prices
  - may increase water availability-because of increased hydroelectric
  - Will lead to adoption of improved irrigation and pumping technologies increased precision
  - May lead to introduction of water trading
- Biofuel
  - Constrained by water-it will affect crop selection
  - Increase demand for water

# Biofuel and land

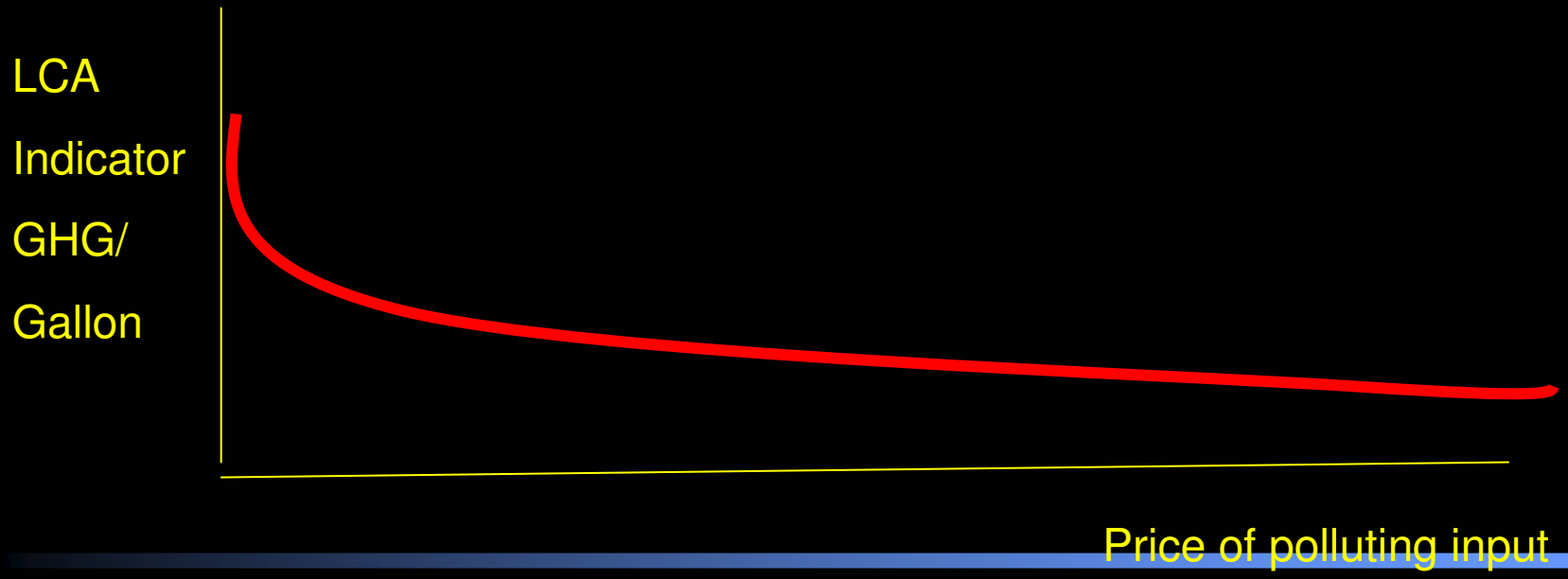
- First generation and surely second generation biofuel is likely to increase land in farming
  - First generation may increase farm land in
    - Eastern Europe
    - South east Asia
    - Tanzania- central Africa
  - Second generation may lead to conversion of bush and forest land to biofuel
- Developing countries  and agency need to develop strategies to increase value added & gain from sunshine and water
  - Don’t fight it
  - Take advantage of it

# Biofuel and climate change

- Carbon (energy) foot print of biofuel is not fixed.
  - It depend on economic conditions
    - Increase of  price of natural gas vs coal
    - may lead to switch to dirtier energy in production and processing
    - increasing carbon use/unit of energy
  - It depends on technologies-
    - increased productivity of biofuel ( biotech) reduces its footprint
  - It depends on regulation -Life cycle limits on GHG/gallon
- Carbon pricing may be easier to implement as means for achieving carbon control targets than LCA based regulations- needs research

# Production economics and Life cycle analysis

- The neoclassical production theory
  - Input use changes to prices- so LCA producing **a function- not a number**
  - So if price of polluting energy increases



# Modeling the effect of a carbon tax when biofuel is processed using coal

*Carbon tax increases the relative price of coal leading substitution by gas and thereby increases net GHG benefits*

| | | | |
|---|---|---|---|
| Exponent for fertilizer | 0.1 | | |
| Exponent for gas in biorefining | 0.1 | | |
| Carbon tax ($/ ton C) | 5 | 10 | 15 |
| % increase in relative coal price | 17% | 35% | 57% |
| **% increase in GHG benefits compared to baseline** | **117%** | **228%** | **383%** |

The greenhouse effect of Biofuel can be reduced if it is processed with say wind Power ( green/ green solution)

# Future of biotech is affected by Innovation

- Needs Better feed stock
  - Cleaner processing
  - Higher productivity agriculture
  - Dissemination and access to technology
- Lessons of electronics and Biotech:Emergence of educational industrial complex-
  - Public/private partnership in R&D and infrastructure
  - technology transfer, start-ups,
- Evolution of industry affected by IPR and regulation
  - IPR: access, sharing arrangement and enforcement
  - Regulations:Land use, carbon content

# Management of risks and uncertainties

- Food is subject to random shocks and so also energy, this implies
  - profitability will leading to cycles of expansion and contraction
  - food security concerns will increase
    - Consumption to stock  ratios of food inventories are declining
    - greater vulnerability to shortages and price increase of food and biofuel
- We need to better understand these risks and efficient arrangement ( insurance, inventories) to control them

# The industrial organization of biofuel

- Energy companies will enter to agriculture and there will be structural changes
  - Strategic alliances between farmer cooperative agribusiness and energy sector
  - merger and acquisition of agribusiness by energy firms
  - Increase reliance on contracting
  - vertical integration - especially in new fuels
- Expansion of farmed land-to range and forest lands
- Biofuel will be part of farming  of industrial commodities

# The integration of agricultural, energy and environmental policies

- Traditional commodity support program become redundant
- Support for biofuel-
  - linked to environmental performance
  - May include some  insurance
  - Government may help establish fuel industry, then it must compete
- Increase food price volatility may warrant government purchases of food to prevent hunger.
- Some conservation land may be returned to production for economic reasons.
- Public sector support for research to develop better biofuels and assess environmental impacts
- Investment in Biofuel will lead to  of foreign direct investment in Developing countries
- Lead to modernization and change in farming- depending on policies and their enforcements

# Policy research challenges – contradictions to be addressed

- Free trade vs. biofuel tariffs
  - Infant industry?  Political capture ?Part of a clever strategy?
  - What are the alternative? Who gains and who is paying?
- Full  gas tanks vs. empty stomachs.
  - Who are the biofuel victims? How to fill stomachs?
- Agribusiness vs. big oil.
  - How to integrate biofuel to the supply chain of the energy sector?
  - Synergies and economics of scope(ship 90% alcohol to refineries)
- Oil vs. water
  - Water institution reform to increase sustainable productivity of water
- Sustainability vs. evolution
  - Develop polices not to preserve the present but to improve the future


Thanks