

# The Low Carbon Fuel Standard and land use change

WSPA Lifecycle Analysis Collaborative

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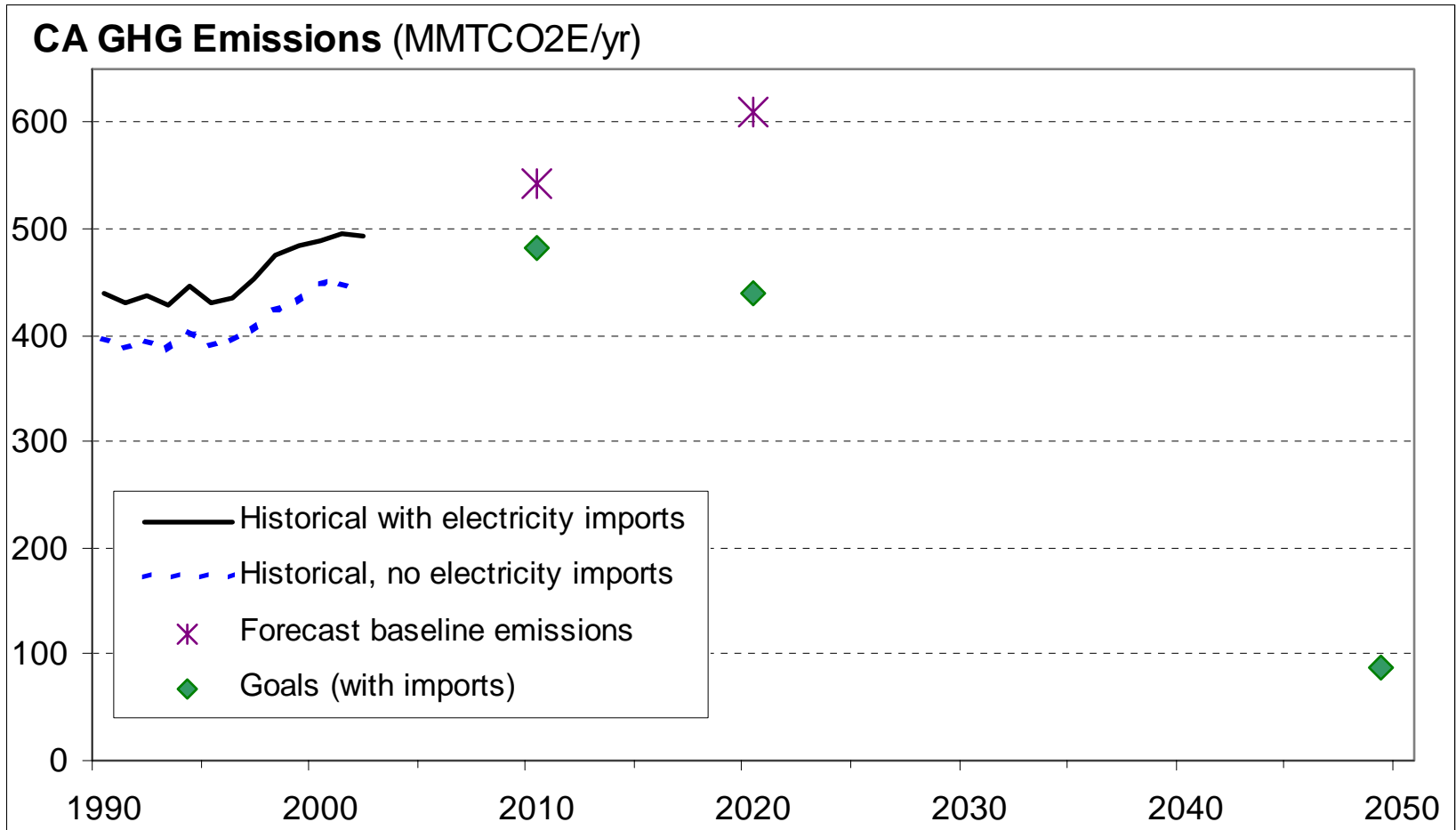
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# LCFS Overview

# California has set ambitious targets



## • Executive Order S-3-05 GHG emission reduction targets

- 2010: maintain 2000 levels (~10% reduction from baseline)
- 2020: return to 1990 levels (~25% reduction from baseline) → **AB32**
- 2050: attain 80% below 1990 levels

# Climate change strategy has three overarching goals

1. **Deploy near-term technologies to cut emissions by ~25% by 2020**
2. **Stimulate innovation & investment in new technologies needed to meet 2050 stabilization targets**
3. **Contribute to related objectives**
  - Economic growth
  - Air quality
  - Affordable energy prices
  - Diversity of energy sources
  - etc.

# California has developed a comprehensive, sectoral strategy to cut GHG emissions

- **Overall goals**

- Executive Order S-3-05
- Global Warming Solutions Act 2006 (AB 32)
- Energy Action Plan, Bioenergy Action Plan, etc.

- **Energy research portfolio**

- **Buildings and appliances**

- Energy efficiency standards

- **Electricity other large sources**

- GHG emissions cap (?)
- Electricity: Carbon adder, Renewable portfolio standard, GHG performance standard, Efficiency targets

- **Transportation**

- Better vehicles – Low GHG standard (AB 1493-Pavley)
- Better fuels - Low Carbon Fuel Standard
- Better transportation systems and planning

- **Other policies**

- Manure management, port electrification, truckstop

**Major unresolved questions:**

Regulations or markets?

How much of California's GHG emissions will be covered in an economy-wide system?

a) Major stationary sources?

b) Natural gas combustion?

c) Transportation ?

d) Agriculture ?

e) All GHG emissions?

# CA LCFS

- **Lower the carbon intensity of transportation fuels**
  - Lower average fuel carbon intensity (AFCI, measured in CO<sub>2</sub>e/MJ) by 10% by 2020
  - Regulated entities are those who manufacture fuels
  - Contribute to overall goal – return to 1990 levels by 2020
- **CARB faces many challenging decisions**
  - Which fuels? (Gasoline? On-road? All?)
  - How to treat light duty dieselization?
  - How to treat electric vehicles?
  - Multimedia and sustainability?
  - **If and how to treat land use change (direct and indirect)**
  - Etc.
- **CARB has asked UC Berkeley & UC Davis to provide support for this process**

# CA LCFS process

- **Rulemaking**
  - Analysis underway now
  - Working Groups are meeting
  - [www.arb.ca.gov/fuels/lcfs/lcfs.htm](http://www.arb.ca.gov/fuels/lcfs/lcfs.htm)
  - Draft discussion language – soon (?)
  - Board decision – December 2008
  
- **Enforceable**
  - 2010
  
- **Fully in effect**
  - 2020

# Why is a Low Carbon Fuel Standard Needed?

- **An economy-wide program (e.g. cap and trade) will be necessary to achieve efficient outcomes**
  - Crucial in the long term as C emissions decline and costs rise
- **Because many market imperfections exist, an economy-wide program will be insufficient**
  - Inadequate R&D (spillover)
  - Inability of government to make credible long-term commitments
  - Market power (petroleum)
  - Coordination (network effects)
  - Externalities (air pollution, energy security, etc.)
  - Uncertainties (climate thresholds)
  - Distributional effects (equity)
- **Transportation lacks fuel-on-fuel competition**
- **In a pure cap and trade system, fuel producers may just buy allowances and pass the costs along to customers**
  - Slows innovation

# Compliance through default and opt-in approach

- **Compliance is possible with many competing technologies:**
  - Lowering the carbon intensity of current fuels – e.g. refinery efficiency
  - Using new, low-carbon fuels – biofuels, electricity, hydrogen, etc.
  - Buying credits (or offsets)
- **Default: all fuel inputs are assigned a carbon intensity**
  - Fuel inputs must be categorized
  - Highest value in common use is the default value
  - Encourages opt-in and focuses management attention
- **Opt-in: certified data allow lower carbon intensity values**
  - Requires protocol development and data collection
  - Certifiers are needed
  - Tends to encourage innovation
- **Default example:**
  - Gasoline: conventional oil, heavy oil, tar sands, coal
  - Diesel: conventional oil, heavy oil, tar sands, coal
  - Ethanol: U.S. corn, Brazilian sugar, U.S. switchgrass

# A carbon price alone is unlikely to effective policy for transportation.

- **Implications of \$12.5/ton CO<sub>2</sub>**

	Price	(wrt retail)
– Nuclear + renewable electricity	0.001 ¢/kWh	(<0.1%)
– Integrated gasification combined cycle with carbon capture and storage	0.125 ¢/kWh	(1%)
– Natural gas combined cycle	0.625 ¢/kWh	(4%)
– Pulverized coal	1.00 ¢/kWh	(8%)
– Gasoline	11 ¢/gal	(3%)
– Corn ethanol (without indirect effects)	6-12 ¢/gal	(3-6%)
- **What is the likelihood that prices like this (escalating at, say, 5% per year) will achieve climate stabilization?**
  - Maybe climate stabilization is the wrong goal, but uncertainties about climate change suggest a precautionary approach.
- **What carbon price *would* make climate stabilization likely?**

# Key challenges for the LCFS

- **Inadequate by itself**

- Without a cap, it would subsidize some GHG emissions

- **Leakage (shuffling)**

- Change in trade patterns
- Global emissions do not change
- Little innovation

- **International trade**

- Developing countries will want to sell low-carbon fuels

- **Life-Cycle Analysis**

- Uncertainties, innovation, plant-specific evaluations, etc.
- Indirect land use

- **Implications**

- International agreements will be needed
- Research and development of regulatory tools is needed

Global consumption: petroleum and biofuels		
California	1%	~7%
United States	25%	~45%
European Union	18%	~10%
Annex 1	58%	~55%
Annex 1 plus (Brazil, China, India, S. Korea, S. Africa)	75%	~100%

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# National and international LCFS developments

- **Many governments are now developing LCFS requirements (or similar)**
- **Carbon accounting is needed no matter what form of climate policy is eventually adopted – although maybe not LCA methods**
- **Indirect LUC is contested, but will be included in the end**

# United States context

- **Energy Policy Act of 2005**
  - Renewable Fuel Standard: 12 billion gallons/yr by 2012 (from ~4)
  - Constant percentage renewable fuels thereafter
  - Advantages for biodiesel, renewable diesel, cellulosic ethanol, etc.
- **2007 State of the Union, Supreme Court, Exec. Order**
- **Energy Independence and Security Act (EISA 2007)**
  - Expansion of original RFS by rule (completed)
  - Total of 36 billion gallons/yr by 2022 (4 categories)
  - Renewable fuels must have lifecycle GHGs 20% below gasoline
  - Federal fuel purchases can be no worse than gasoline
  - Indirect land use must be included
- **Tax credits for domestic biofuel production, tariffs against imports, Farm bill (?)**

# United Kingdom context

- **Climate change policies starting 2000**
  - 2006 forecast: 23%-25% reduction by 2010 (from 1990)
  - 2007 Climate Change Bill: 26%-32% reduction by 2020 and 60% reduction by 2050
- **Biofuels were 0.25% of road fuel in 2005, ~50% imports**
- **Declining North Sea production → net oil imports in 2007**
- **Renewable Transportation Fuel Obligation (RTFO)**
  - Announced Nov05, starts Apr08, and is to achieve 5% by 2010
  - Requires carbon and sustainability reporting, *not* indirect land use
  - Biofuels must have lower GHGs than baseline: 40%-50% reduction
- **Renewable Fuels Agency to review indirect land use and report by May08**
  - <http://www.dft.gov.uk/pgr/roads/environment/rtfo/biofuelsreviewtor>

# German context

- **National Climate change goals**
  - 2008-2012 reductions of 21% (from 1990)
  - Continued GHG emission reductions
- **Biofuel Quota Act (Jan07)**
  - 6.75% in 2010, to increase 0.25% per until 8% in 2015
- **Biofuel Sustainability Ordinance (Dec07)**
  - Sustainable cultivation, habitat protection, GHG reduction
  - GHGs
    - Default and opt-in
    - Energy-based allocation for coproducts
    - Direct LUC is considered (20 years)
    - "...the Federal Government plans to continue promoting further study of the indirect effects of land utilization changes vigorously in order to amend Annex 2 accordingly as soon as possible, thereby contributing to the discussion within the EU."

# European Union context

- **GHG Emissions Directive (2003/87/EC)** - a law
  - 20% reduction in GHGs by 2020 (as modified Jan08)
- ***Biofuels Directive (2003/30/EC)*** - a law
  - Target of 2% biofuels by 2005 (not met, only 1.4%)
  - Set a target of 5.75% biofuels by 2010
- **EU Commission decision (Jan08)** - just a bill
  - Set a target of 10% biofuels by 2020
- **Proposed *Fuel Quality Directive*** - just a bill
  - Fuel suppliers lower carbon intensity 1%/yr starting in 2010
- **Proposed *Renewable Energy Directive*** - just a bill
  - Biofuels must be have GHG emissions at least 35% below fossil
- **Common Agricultural Policy (CAP) and other agricultural policies** - laws

# EU GHG measurement methodologies

- **GHG calculation methods will be in the legislation itself**
  - Under development, could be resolved in June08 to Dec08
    - [http://ec.europa.eu/energy/climate\\_actions/doc/2008\\_res\\_ia\\_annex\\_en.pdf](http://ec.europa.eu/energy/climate_actions/doc/2008_res_ia_annex_en.pdf)
  - Default and opt-in approach
  - Co-product allocation by energy
- **Land use change**
  - 20 year timeframe with no discounting (but 100 year GWI values)
  - Direct land use will be included
  - Proposals for indirect land use appear to be contested, but the current idea is to ignore indirect land use
    - Citing FAO, the EC argues that "...the main impact of increased biofuel demand will be a further increase in productivity, not an increase in the quantity of land used for agriculture...For cereals [during 1980-2006], all of the increase in production came from increases in productivity and none from increases in land devoted to these crops." (pp. 144-145)

# International efforts

- **Global Bio-Energy Partnership**
  - Will develop a checklist and a set of questions when considering biofuel policies and projects
- **Roundtable on Sustainable Biofuels**
  - Developing a GHG measurement protocol, but the status of land use change is unclear
  - Some are viewing this as a potentially important voluntary labeling effort
- **Roundtable on Sustainable Palm Oil**
  - ???

## Land use change

- **General agreement that indirect land use change occurs**
- **The size of the GHG emissions from indirect LUC is poorly understood – 1 data point so far (Searchinger et al 2008)**
- **There are many groups studying indirect LUC**
- **Decisions must be made before all the uncertainties about indirect LUC are resolved**

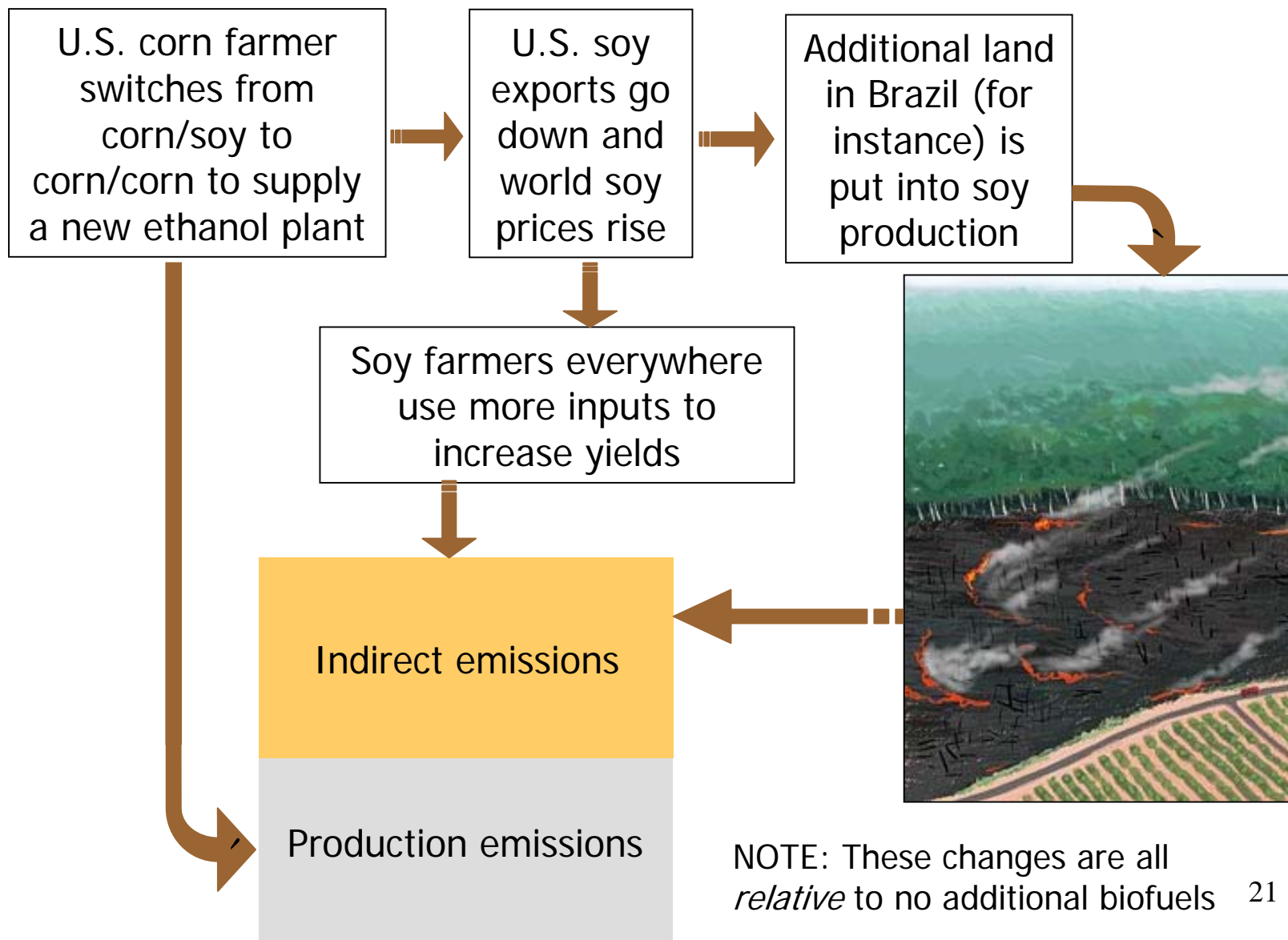
# Indirect effects (aka “market-mediated”)

- **There is widespread agreement that competition for land exists**
  - Delucchi (1993, 2004, 2005) first discussed these effects in the context of biofuels
- **There are several relevant studies of this phenomenon**
- **It is not clear how best to treat these effects in a regulatory context**
- **Similar questions may arise about other effects**
  - Albedo changes, evapotranspiration, N cycle, etc.

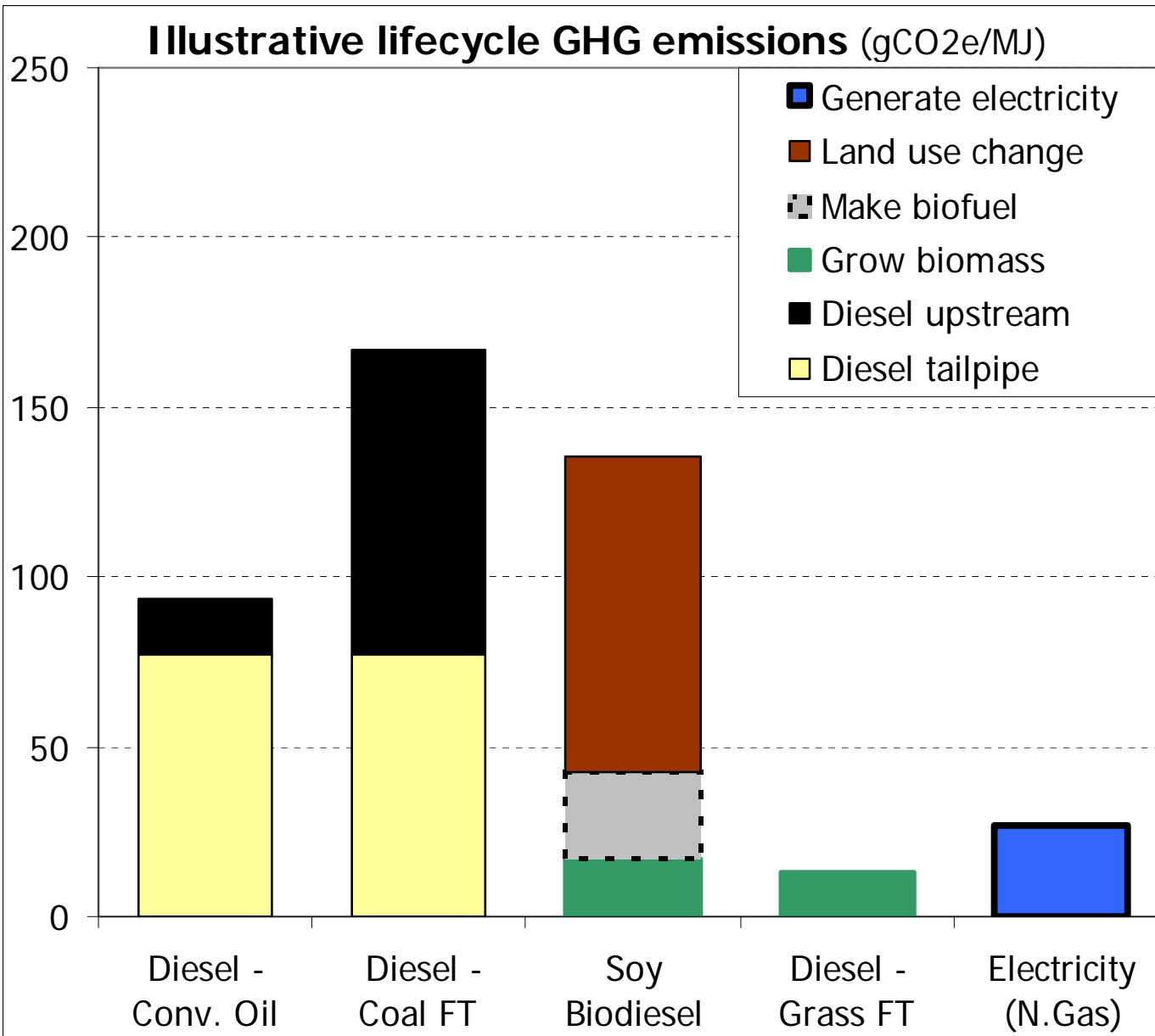
Note: Other fuels may also cause indirect effects, besides biofuels

# Market forces cause indirect GHG emissions

(Land use change is only one indirect effect)



# Indirect LUC may be a game changer



## Notes:

**Illustrative values only**

**FT = Fischer Tropsch**

**LUC values from Searchinger et al 2008**

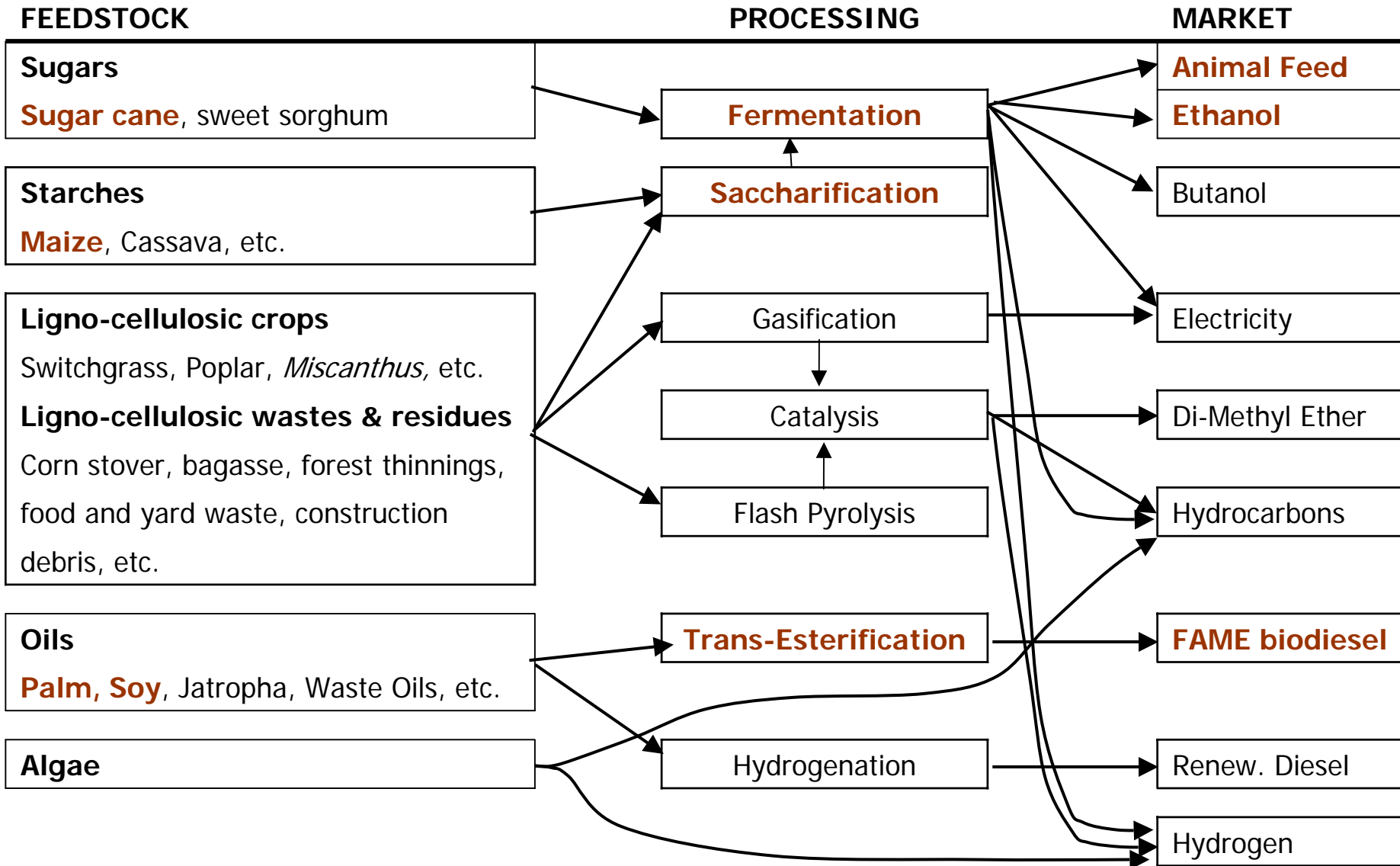
**Grass FT from Hill et al 2006 and assumes degraded land**

**Electricity: combined cycle generation and 5x drivetrain efficiency**

# Biofuels that do not compete with food and wilderness for fertile land avoid the risk of indirect GHG emissions

- **Wastes and residues**
  - Municipal solid waste, rice hulls, corn stover, etc.
- **Agricultural integration**
  - Winter cover crops (e.g. mustard), high-cellulose food crops (e.g. soybeans), etc.
- **Biofuels that use wastelands or degraded lands**
  - Mixed prairie grasses, Switchgrass, Miscanthus, Jatropha, Sweet sorghum, Algae (?)
- **Other (?)**
- **Some of these products can be available soon, but more R&D is needed**

# Many biofuel pathways are possible



Partial representation – not all possibilities are shown

# Research on market-mediated effects of biofuel production

# LCA Methodologies

- **Delucchi 2002**
  - Makes case for economic integration in analyzing transportation fuels
- **Ekvall and Weidema 2004**
  - Describe “consequential” LCA from a theoretical standpoint
  - Must include marginal effects in markets for displaced goods
- **Kloverpris et al. 2008**
  - Application of consequential LCA to Land Use
  - Suggest Global Trade Analysis Project (GTAP) model as a suitable economic tool

# Equilibrium models

- **Markets are in equilibrium**
  - Solve for prices of goods, services and factors of production so quantities supplied equals demand.
  - General – all markets but little detail
  - Partial (or sectoral) better representation of specific issues
- **Both physical goods and money are conserved.**
- **Many assumptions about perfect markets**
- **Econometric studies are used to determine parameters**
- **Can include trade, investment, technologies, land, and ...**
  - Can begin to look like a magical crystal ball
  - The more future conditions differ from the past, the less reliable
- **Integrated Assessment Models (IAMs) combine economic and climate science models (IAM = CGE + GCM, sort of)**

# CGE and Integrated Assessment Model (IAM) Methodologies

- **Forthcoming book edited by Hertel et al.**
  - See Hertel et al. 2008 Working Paper on LU in CGE
- **Huey-Lin et al. 2005**
  - Describes agroecological zone approach used by GTAP
- **Schlosser et al. 2007**
  - Framework for land use change in MIT's Integrated Global System Model (IGSM)

# Equilibrium model assessments of biofuels

- **Johansson and Azar 2006**
  - LUCEA model, includes carbon tax and land rents, but not GHG emissions from land conversion
- **Birur 2007**
  - GTAP model, focus on foods prices
- **Wescott 2007**
  - USDA model, focus on commodity prices
- **Tokgoz 2007**
  - FAPRI model, forms basis for Searchinger
- **Reilly 2007**
  - MIT's IGSM model, focus on total land needs
- **Gurgel 2008**
  - MIT's IGSM model, examines land use change, but not GHGs
- **Baker 2008**
  - Stochastic FAPRI model, impact of EISA 2007

# Integrated CGE and GHG Assessments, Capable of Feeding into LCA

- **Some of the previous studies are close, but lack GHG impacts per unit fuel**
- **Searchinger et al. 2008**
  - FAPRI model with large shock, Woods Hole C data
  - No endogenous intensification margin
- **EPA analysis**
  - FAPRI and FASOM models
- **UC / Purdue Study for CARB**
  - GTAP model ([www.gtap.agecon.purdue.edu](http://www.gtap.agecon.purdue.edu))
  - Global Trade Analysis Project
  - 8-region model with explicit land use by agro-ecological zone
  - Intensification will be included

# Primary Models

- **GTAP (Global Trade Analysis Project)**
  - Global CGE with explicit treatment of land
- **FAPRI (Food and Ag Policy Research Institute)**
  - Global Partial Eq of ag sector
- **IGSM (Integrated Global Systems Model)**
  - Integrated assessment model including a CGE, terrestrial ecosystem model, climate feedbacks etc.
  - The CGE model in this system, EPPA, uses the GTAP database
- **LEI - IMAGE**
  - LEI is a Global CGE based on GTAP
  - Crop yields, land cover, climate feedbacks, and GHG emissions handled by IMAGE, a spatial bio-physical model
- **FASOM GHG**
  - Partial equilibrium model of US forestry and agriculture incorporating GHG emissions

# Current disagreements

- **Sources**

- [www.princeton.edu/~tsearchi](http://www.princeton.edu/~tsearchi)
- [www.transportation.anl.gov/pdfs/letter\\_to\\_science\\_anldoe\\_03\\_14\\_08.pdf](http://www.transportation.anl.gov/pdfs/letter_to_science_anldoe_03_14_08.pdf)
- [www.newrules.org/de/Ethanol-and-Land-Use.pdf](http://www.newrules.org/de/Ethanol-and-Land-Use.pdf)
- <http://newfuelsalliance.blogspot.com/2008/02/more-misleading-biofuels-analysis.html>

- **Main claims**

1. Ignores crop yield increases
  2. Conversion of pristine cropland
  3. Too large a volume of corn ethanol
  4. Incorrect prediction of export decline
  5. U.S. corn exports have increased so ethanol does not affect imports
  6. Insufficient credit for coproducts
  7. Many factors influence deforestation
- Etc.

## **Response**

Uses historical rates (but not price-induced)  
Assumes many types of LUC, and that using pasture land does not lead to further LUC  
Effect is largely linear, rate is reported  
Prediction is for 30B gallons, and is relative to scenario without corn ethanol  
Corn acreage has gone up even more, and corn and soya stocks declined greatly  
Study is consistent with USDA analysis  
Study only looks at ethanol-induced change

# CARB plans to address LUC in the LCFS

# CARB faces two distinct questions

- **How large is the indirect LUC effect?**
  - There are more complex and subtle versions of this question, obviously
- **What, if anything, should be done about indirect LUC in the LCFS regulations?**

# Regulatory implications seem unclear now

- **Ignoring indirect LUC has little scientific support**
- **The complexities and uncertainties of indirect LUC make it difficult to decide what to do**
- **Applying indirect LUC to the baseline for the LCFS (e.g. 2006) may make a “better biofuels” strategy possible**
  - May not help achieve the goals of AB32, which has a 1990 baseline
- **More analysis will help, but decisions will have to be made before all uncertainty is resolved (even a decision to take no action)**

# Future research needs

- **Reconciling economic growth, energy security, poverty alleviation, and climate protection**
  - Policies and programs that benefit all countries need a solid scientific foundation.
  - Analysis of economic and health impacts on the poor is needed
- **Improving the data for land use change modeling**
  - Understand *future* patterns of land use change, by country
  - Better understanding of price-induced yield improvements
  - Characterization of grassland, wetland, and forest feedstocks
  - Modeling the use of degraded lands
- **Analysis of advanced biofuels**
  - Improvements in starch/sugar (generation 1)
  - Representation of generation 2+
- **Further analysis of uncertainty**

# Thank you

## UC team members

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