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BioEnergy
Fueling America Through Renewable Resources

Estimating GHG Emissions Due to Land Use Changes Induced by Biofuels

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Background

- Prior to 2007, the general consensus was that corn ethanol reduced greenhouse gasses a bit more than 20% after considering all the direct effects related to growing the crop, transporting, processing, and consuming the ethanol.
- That is probably why the EISA of December 2007 included the 20% requirement for corn.

Background

- By the second half of 2007, the importance of indirect land use change induced emissions was circulating among professionals in the area.
- The EISA included a requirement that indirect land use changes be considered in estimating total GHG impacts for biofuels.
- In February 2008, *Science* published a paper by Tim Searchinger and faculty/staff from Iowa State University.

Background

- The *Science* paper argued that rather than reduce GHG, biofuels, especially corn based biofuels, actually cause substantial increases in GHG.
- Essentially, the argument is that if you divert an acre of corn from feeding animals to feeding an ethanol plant, the animals still have to be fed. As this cycles through the global economy, ultimately it results in reduction of forest and pasture thereby releasing GHG and reducing future carbon sequestration.

Introduction

- Background – economics perspective
- No choice but to do the best job we can measuring the land use and GHG emissions changes due to biofuels
- Issues
  - Conceptual modeling issues: GE, PE, other
  - Baseline
  - Technical change
  - Data
- Must deal with uncertainty

Conceptual Modeling Issues

- Boundaries
- Handling of linkages among sectors and regions
- Comparing marginal with marginal or average with average
- Coming up with good ways to decide what is important to include and what we can safely ignore at least for now – a good way to screen
- Capturing the uncertainty in our analysis

More Conceptual Issues

- Getting the intensive and extensive margins correct in our models
  - Intensive margin – price induced yield increases
  - Extensive margin – bringing in the right land at the correct (lower) yield
  - Handling investments in land conversion

Baseline

- So many of the effects are linked. What do we need to consider to be able to isolate the effects of biofuels?
  - Energy prices – major biofuels driver
  - Demand – population, incomes, etc.
  - Supply – yield increases, policy on idled land, water supply issues, environmental issues
  - Exchange rates
  - Policies in the rest of the world
- Can we isolate biofuels impacts and hold the rest constant?

Technical change

- How should we handle technical change?
  - Future improvements in conversion technologies
  - Future improvements in yields
  - Future changes in other energy technologies
- Does the decision on any of these issues affect in an important sense the impact of a biofuels program?
- May be best handled on a scenario basis

Data

- Current land use and land cover.
- What are the most important global areas to make sure we have right?
- Land productivity by land type.
- Yield increases induced by higher prices.
- Changes in demand for agricultural products.

EPA May 2009 Draft Ruling

- These results will be subject to further peer review.

Fuel Pathway	**Range**
Corn ethanol (natural gas)	+5% to -16%
Corn ethanol (best case)	-18% to -39%
Soy biodiesel	+4% to -22%
Sugarcane ethanol	-26% to -44%
Switchgrass ethanol	-124% to -128%
Corn stover ethanol	-116% to -115%

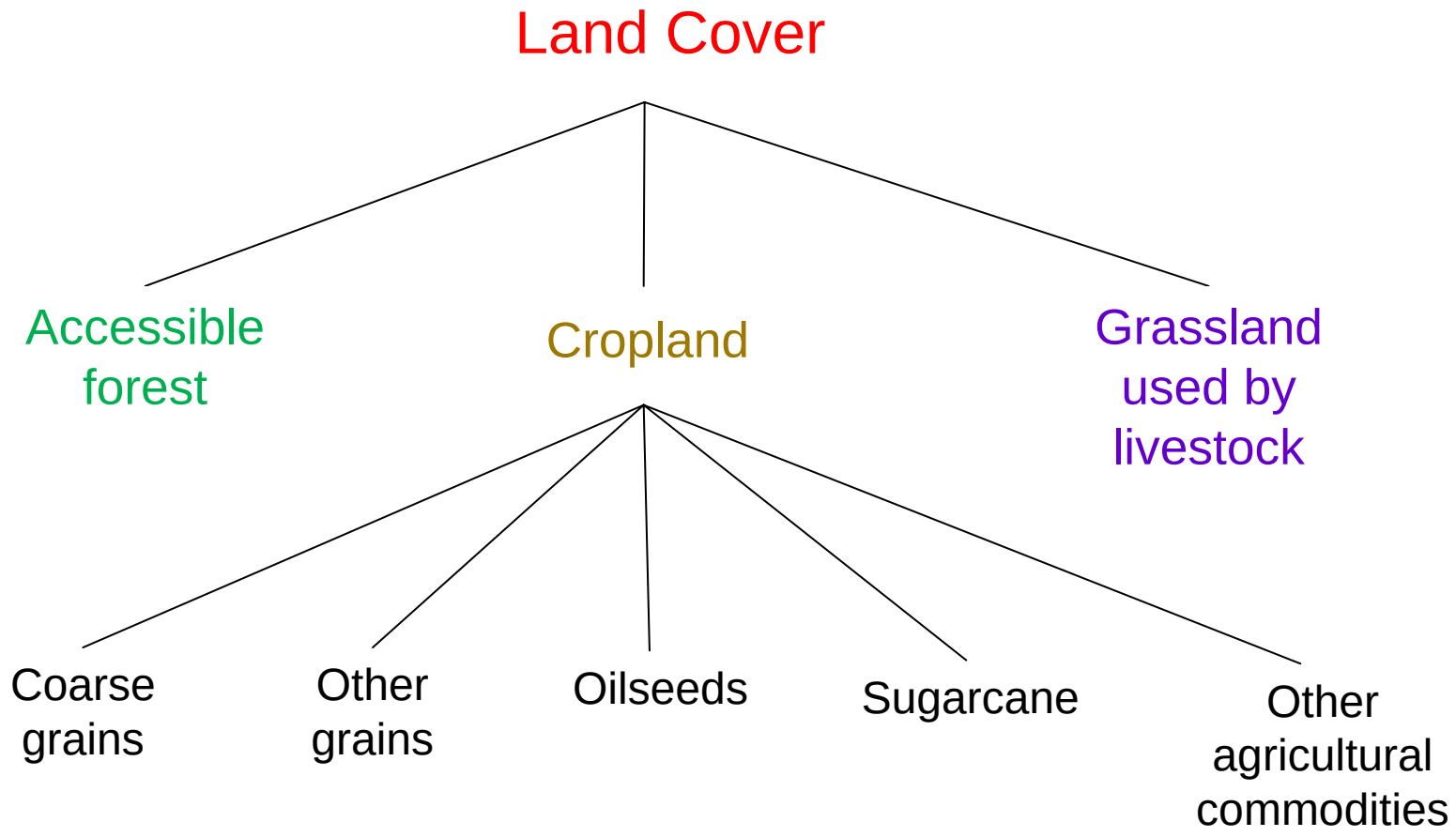
EPA May 2009 Draft Ruling

- Standard corn ethanol is marginal when compared with the 20% reduction requirement.
- All existing corn ethanol capacity is grandfathered, so it does not really matter.
- All cellulosic feedstocks meet the standard.

Introducing Biofuels into the GTAP database

- GTAP Database Version 6:
  - Original database represents 2001 world economy (87 regions and 57 commodities)
  - New database, GTAP-BIOA (87 regions and 60 commodities)
    - Ethanol 1 produced from coarse grains,
    - Ethanol 2 produced from sugarcane,
    - Biodiesel from oilseeds .
  - New database, GTAP-BIOB (87 regions, 62 commodities, and 60 industries)
    - DDGS - byproduct of ethanol 1,
    - Meals - byproduct of biodiesel.
  - Data on production, consumption and trade of biofuels are obtained from International Energy Agency (IEA)
  - Aggregation scheme (18 regions, 22 commodities, and 20 industries)

Land Cover in GTAP: By Region at AEZ Level



Implications of Biofuels for Agriculture & Livestock

- Higher crop prices which lead to:
  - Higher input costs,
  - Higher land prices,
  - Conversion of some pastureland and forest to crops,
  - Lower demand for final products of processed livestock industries,
- Biofuels are produced in conjunction with valuable byproducts
  - Distillers dried grains with solubles (DDGS) and oilseed meals are the main biofuel byproducts,
  - These byproducts can be used in the livestock industry as animal feeds,
- Biofuel byproducts can help to offset some of the adverse cost implications of the biofuels boom for the livestock industry.

An Improvement in GTAP-BIO Model and Database

The new model covers 28 sectors, 30 commodities, and 18 Regions

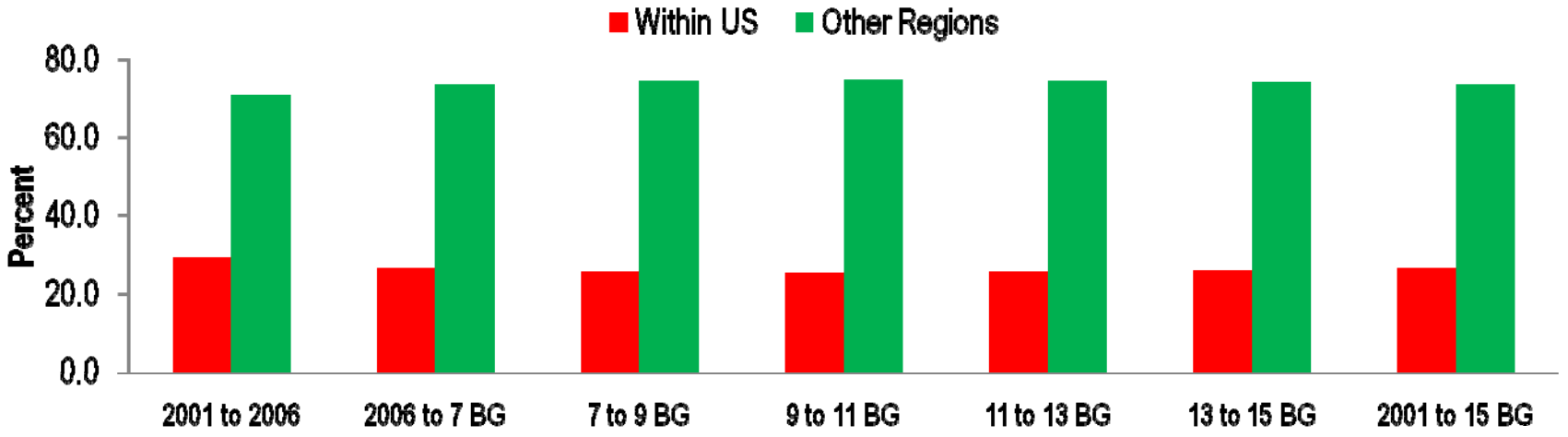
- Biofuel products are:
  - Ethanol from coarse grains: Mainly US,
  - Ethanol from sugarcane: Mainly Brazil,
  - Biodiesel from vegetable oils: Mainly EU.
- Byproducts are:
  - DDGS,
  - Oil meals.
- Livestock industries are:
  - Dairy Farms,
  - Other Ruminant,
  - Non-Ruminant.
- Processed livestock industries are:
  - Processed dairy products,
  - Processed ruminant products,
  - Processed non-ruminant products.

- Agricultural products are:
  - Coarse grains,
  - Other grains,
  - Oilseeds,
  - Sugarcane,
  - Other agriculture products.

- Other commodities:
  - Forest products,
  - Processed food,
  - Beverages, tobacco, and …. ,
  - Processed feed,
  - Crude vegetable oil,
  - Edible vegetable oil,
  - 5 non-biofuel energy commodities,
  - 3 other commodities and services.

Land Use Changes Due to the US Ethanol Program

Change in ethanol	2001 to 2006	2006 to 7 BG	7 to 9 BG	9 to 11 BG	11 to 13 BG	13 to 15 BG	2001 to 15 BG
Change in Cropland (1000 Hectares)	562.0	358.0	359.0	367.6	375.6	384.4	2406.6



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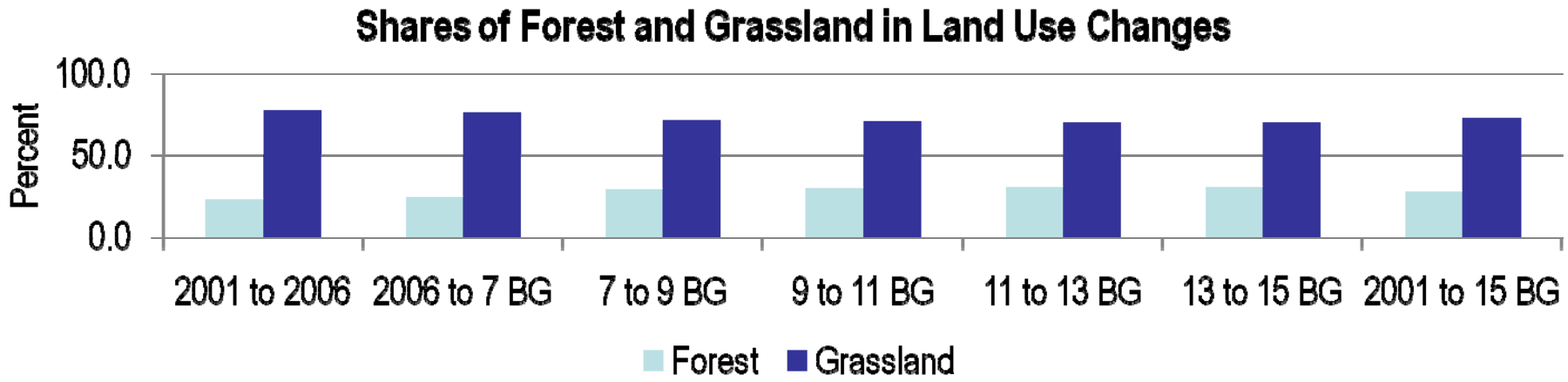
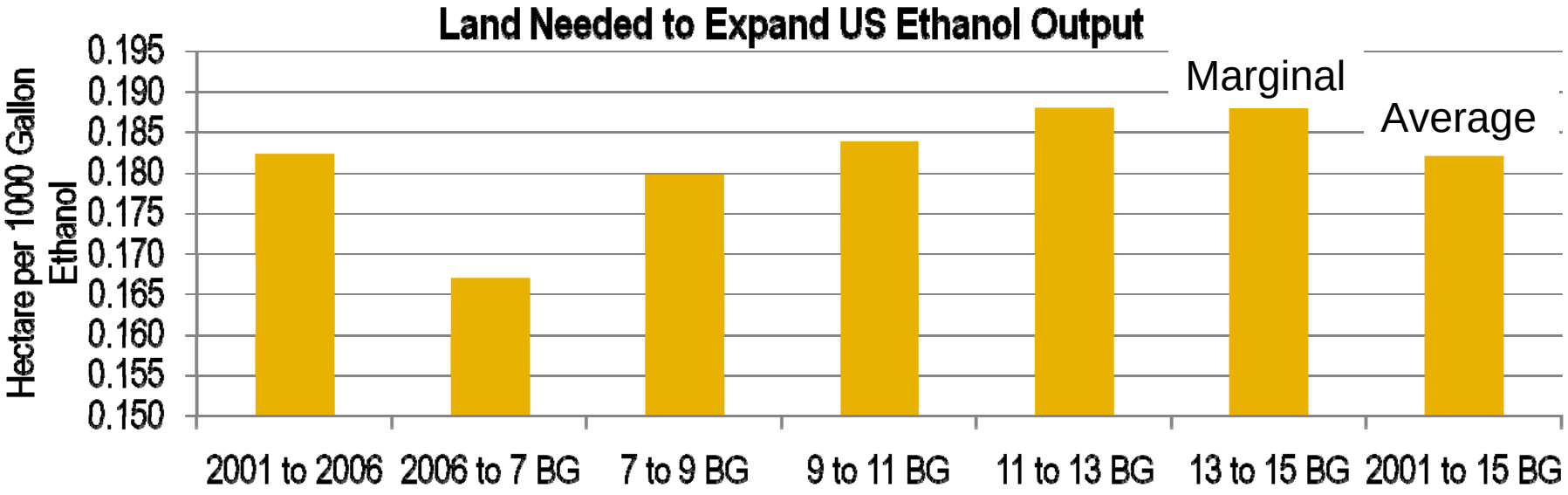
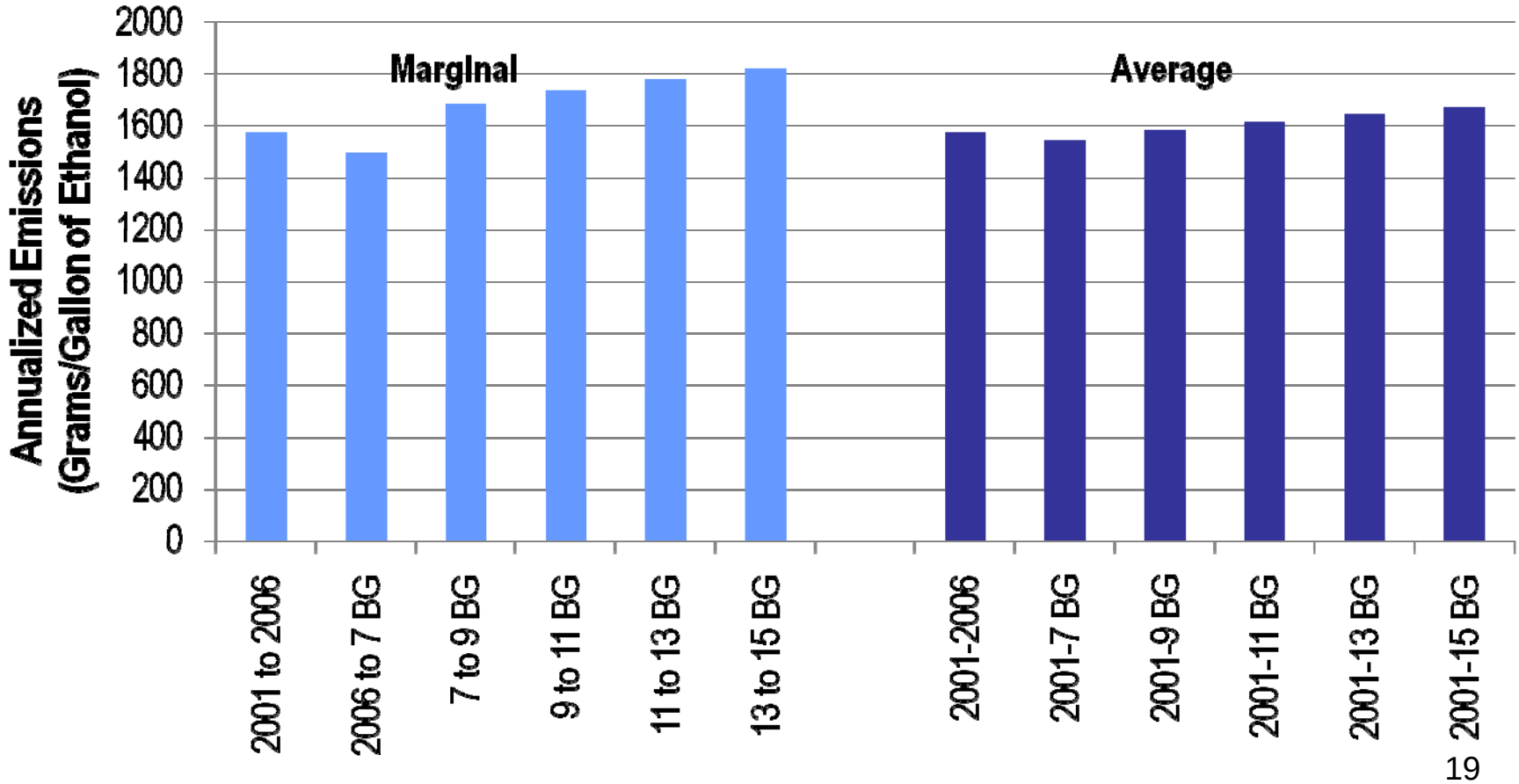
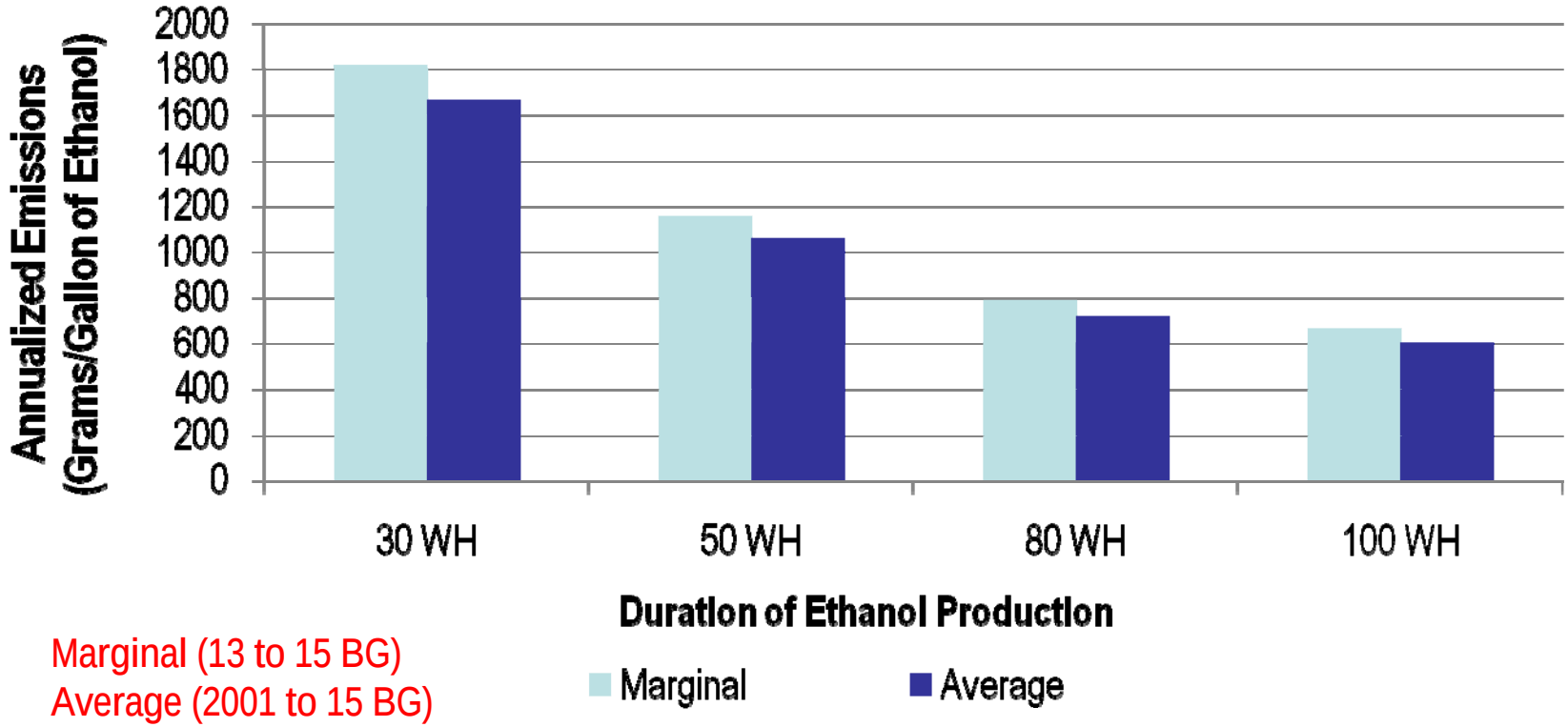




Land Use Emissions Due to the US Ethanol Program GHGs Emissions - 30 Years Woods Hole



Land Use Emissions Due to the US Ethanol Program GHGs Emissions - Several Durations of Production



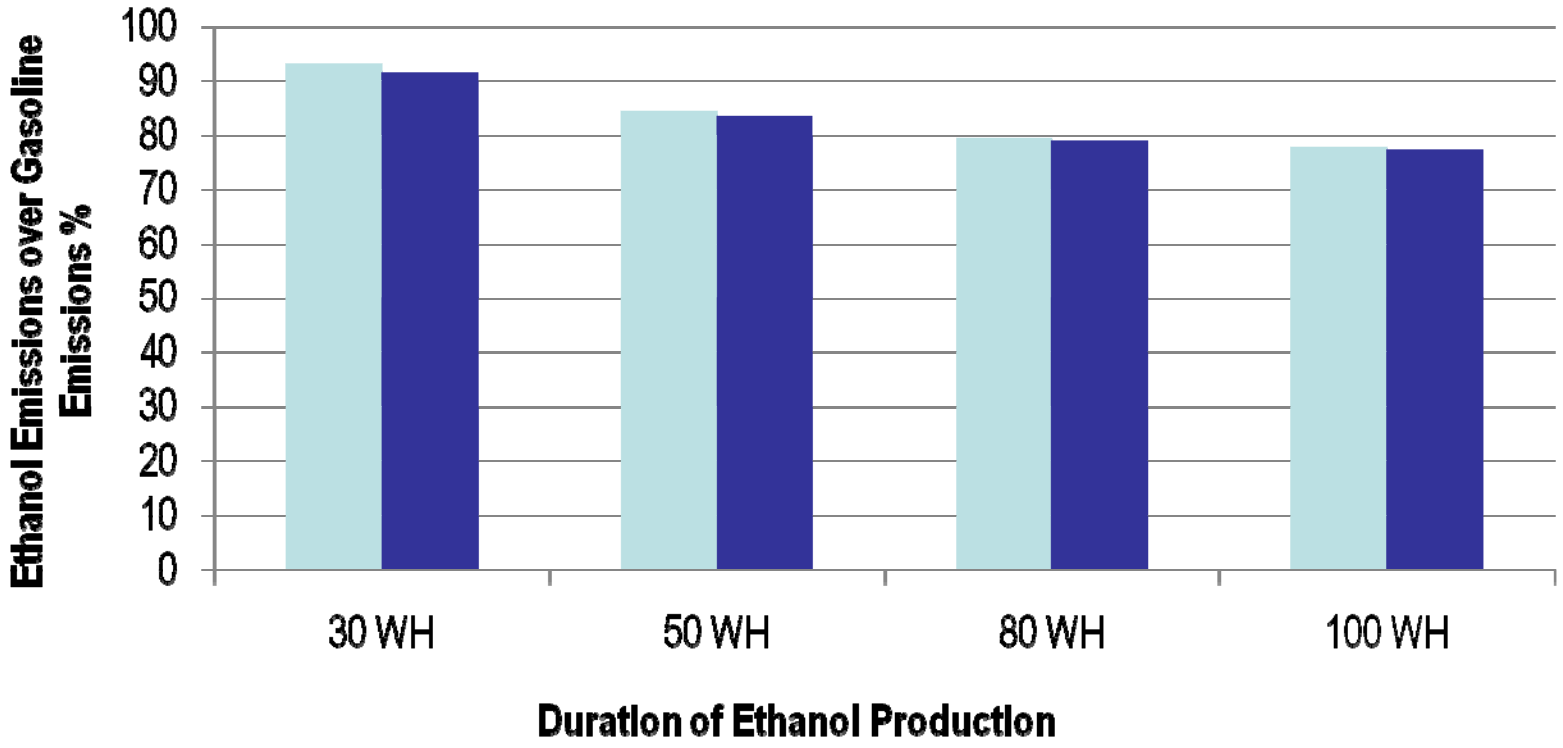
Marginal (13 to 15 BG)
Average (2001 to 15 BG)

Land Use Emissions Due to the US Ethanol Program Searchinger et al. 2008 vs GTAP Results

Searchinger et al. (2008)	Total Emissions for 30 years (million metric tons)	3801
	Change in ethanol production (billion liters of ethanol)	55.92
	Total emissions for 30 years (grams per liter)	67972
	Liters per gallon	3.785
	Total emissions for 30 years (grams per gallon of ethanol)	257302
	One year emissions (grams per gallon of ethanol)	8577
GTAP	One year average emissions (grams per gallon of ethanol)	1666
	One year marginal emissions (grams per gallon of ethanol)	1817

GTAP average 19.4% of Searchinger, et al.

Land Use Emissions Due to the US Ethanol Program
Total Ethanol vs Gasoline Emissions per Mile



Marginal (13 to 15 BG)
Average (2001 to 15 BG)

GTAP Results Summary

Item	Units	Value
Annual average emissions	Gm./gal.	1666
% of Searchinger	%	19.4
Average Ethanol emissions	Gm./mi.	444.5
% of gasoline	%	91.3

- For the 100 year horizon, our results are 23% of gasoline.
- There is huge uncertainty surrounding these results.
- However, we know the land use change is not zero.

Comparison Basis

- As is clear from these results, there is a difference. between emissions calculated on an average basis and a marginal basis.
- The same would be true for the petroleum base case.
- Economics would argue for using a marginal comparison instead of the average we are now using.
- For petroleum, the marginal source likely would be Canadian tar sands or heavy Venezuelan crude – both of which would have higher GHG emissions than the standard sources.
- This issue deserves more attention.

Summary

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- Our current corn ethanol numbers bracket the EISA standard, and they are uncertain.
- However, they represent good science, and, like other economic modeling can never be perfect.
- Technology improvements on the direct emissions side may lower the total more than any future changes in indirect emissions.