

# **Costs and benefits of transportation biofuels**

Southeastern Universities Research Association

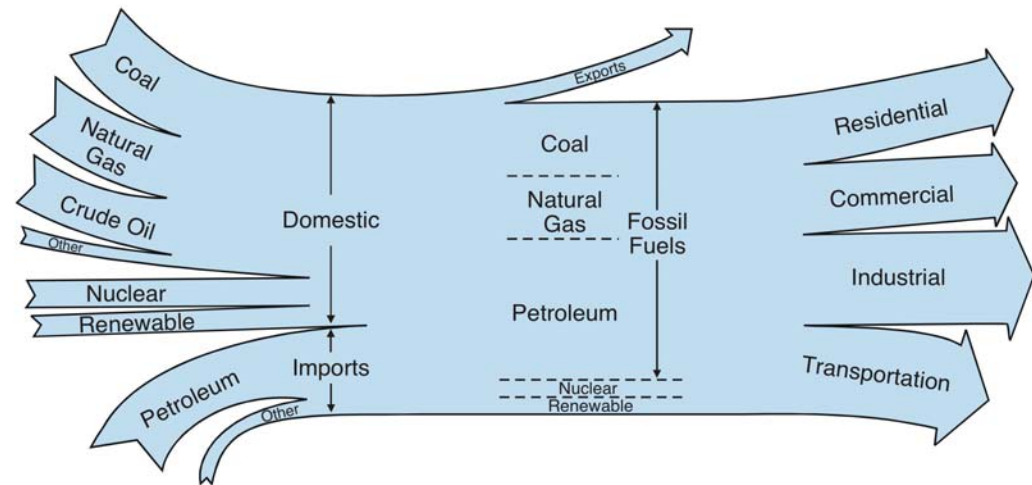
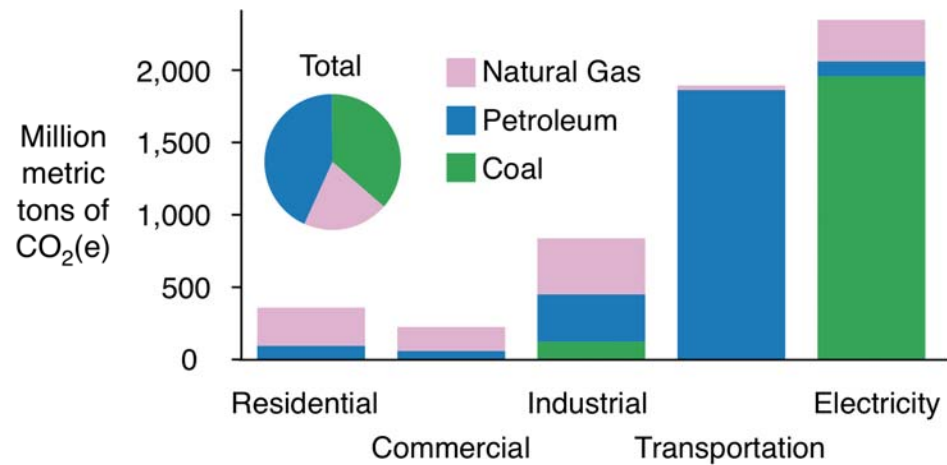
August 11, 2009

**Jason Hill, Ph.D.**  
**Institute on the Environment**  
**University of Minnesota**  
**hill0408@umn.edu**



# The search for petroleum alternatives

- Supply volumes
- Supply stability
- Record prices
- Greenhouse gas emissions
- Overwhelming dependence upon oil for transportation



# Striving for energy independence



**85% LESS FOREIGN OIL.**

CleanAirChoice.org

*Flip your lid!*

**E85**  
85% Ethanol



**ETHANOL INCREASES AMERICA'S ENERGY SECURITY.**

Biodiesel Facts	
Amount per Gallon	
% Driving Values	
Renewable Fuel	100%
Cleaner Burning	100%
Made in America	100%
Dependence on Foreign Oil	0%

# Biofuels as a green alternative

**E85: explained**  
cornulator  
stalk car race  
get stuff  
go yellow links

**livegreen goyellow**

**E85 is here**

Thanks to GM's pioneering efforts to make cleaner E85 ethanol a viable alternative to gasoline, there are over 2 million GM FlexFuel Vehicles on the road that are capable of running on E85. Discover how E85 ethanol can change our landscape for the better.

**FLEXFUEL**  
E85 ETHANOL

[E-mail this link](#)

What is E85? **Only GM**

**BIOWILLIE**  
Premium Diesel Fuel

**BIOFUELS**

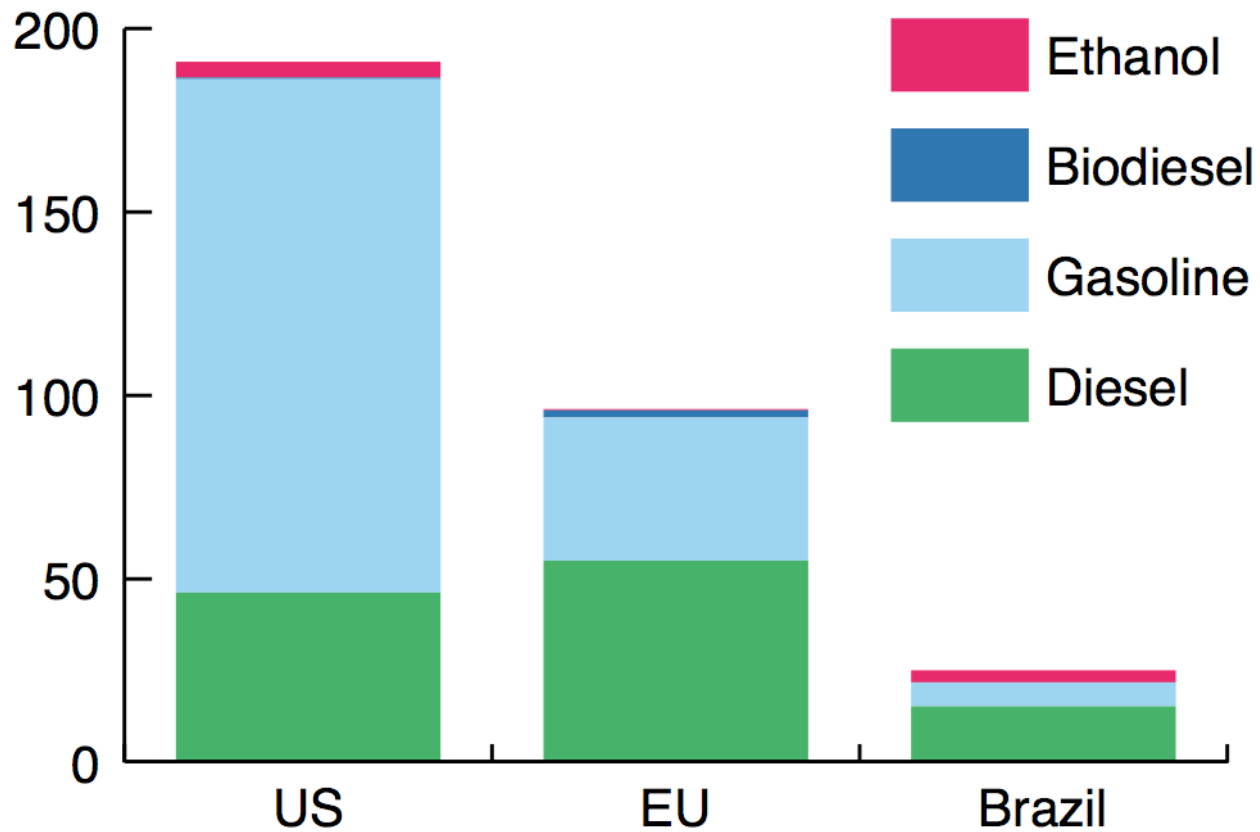
- Clean burning, renewable fuel.
- Reduces dependence on foreign oil.
- Provides superior torque and performance.
- Ready to use in your engine today.

**Why pump your fuel when you can grow it?**

**ETHANOL PROTECTS THE ENVIRONMENT.**

# Three largest biofuel producers in 2007

Billion gallons  
(gasoline equ.)



# A lengthy debate

## Gasohol: Does It or Doesn't It Produce Positive Net Energy?

R. S. Chambers, R. A. Herendeen, J. J. Joyce, P. S. Penner

*Summary.* A detailed analysis of energy inputs and outputs is performed on grain-based gasohol (10 percent grain-based ethanol, 90 percent gasoline). Existing differences of opinion on the energy balance derive mainly from variations in interpretation which are several examples of inherent methodological problems in energy analysis. The result is strongly dependent on assumptions about use of crop residues for fuel and the miles-per-gallon rating of gasohol. In terms of total nonrenewable energy, gasohol is close to the energy break-even point. On the other hand, in terms of petroleum or petroleum-substitutable energy, gasohol is an unambiguous energy producer, since most energy inputs to the process can be supplied by nonpetroleum sources such as coal.

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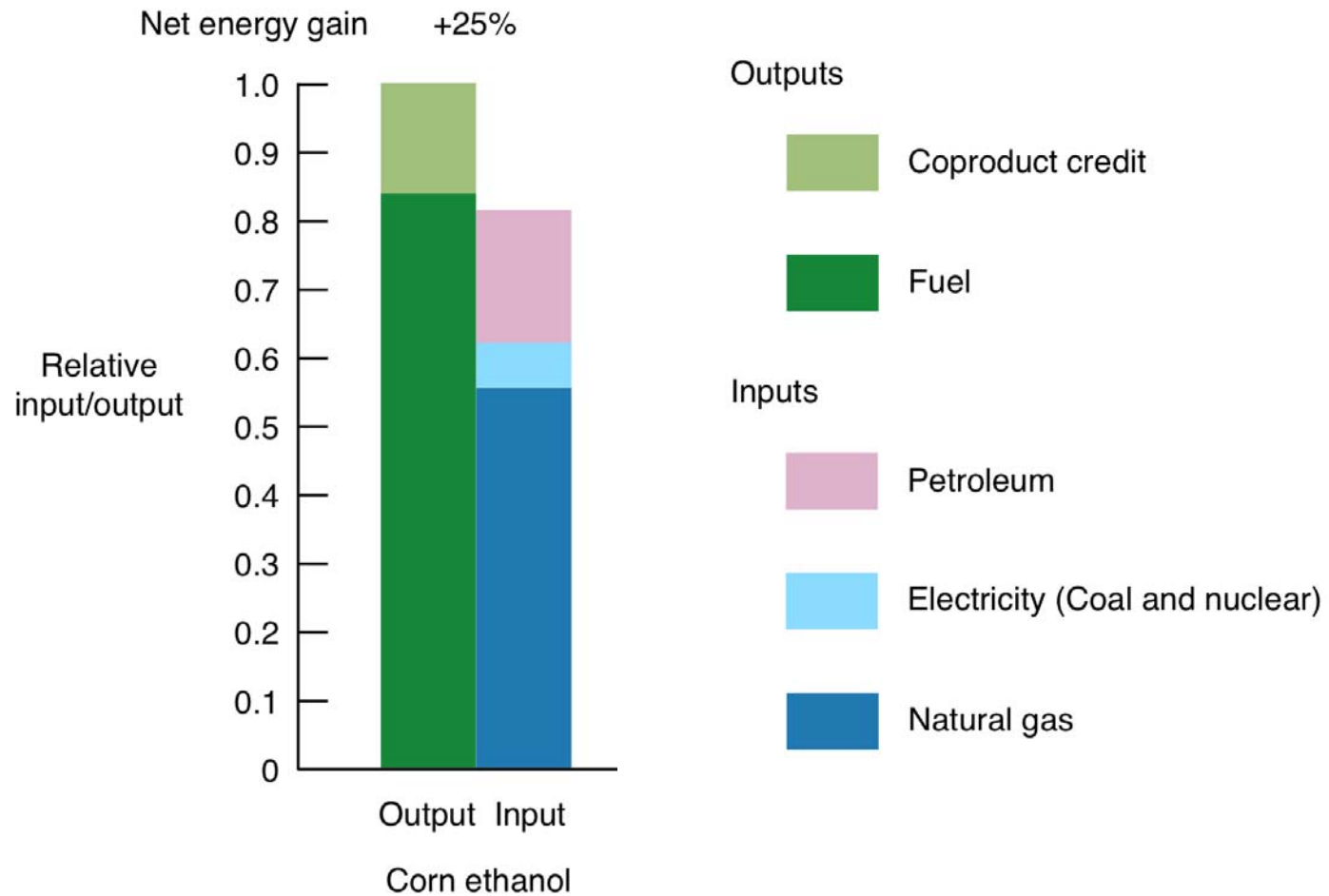
## Ethanol Can Contribute to Energy and Environmental Goals

Alexander E. Farrell,<sup>1\*</sup> Richard J. Plevin,<sup>1</sup> Brian T. Turner,<sup>1,2</sup> Andrew D. Jones,<sup>1</sup> Michael O'Hare,<sup>2</sup> Daniel M. Kammen<sup>1,2,3</sup>

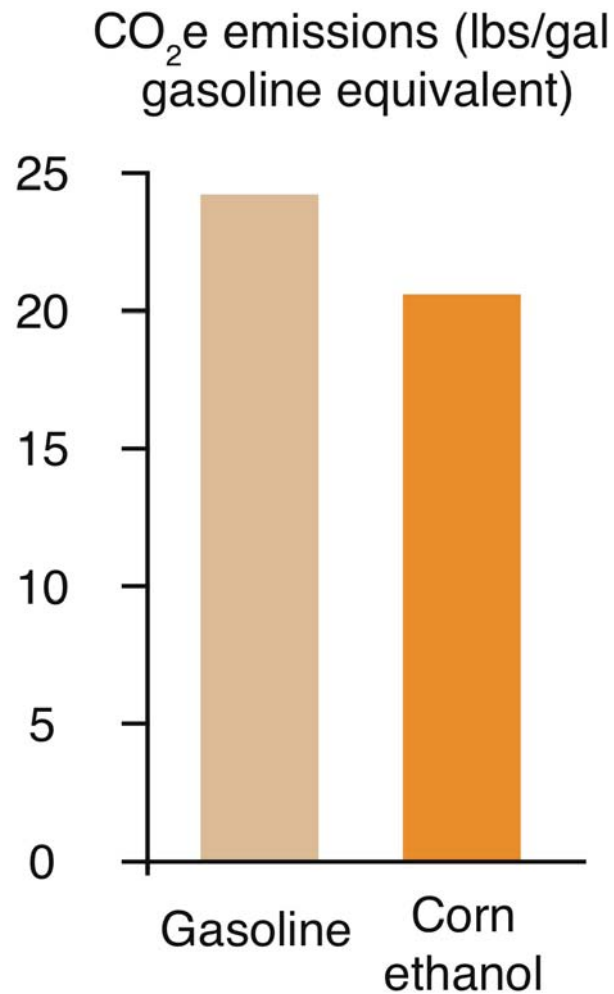
To study the potential effects of increased biofuel use, we evaluated six representative analyses of fuel ethanol. Studies that reported negative net energy incorrectly ignored coproducts and used some obsolete data. All studies indicated that current corn ethanol technologies are much less petroleum-intensive than gasoline but have greenhouse gas emissions similar to those of gasoline. However, many important environmental effects of biofuel production are poorly understood. New metrics that measure specific resource inputs are developed, but further research into environmental metrics is needed. Nonetheless, it is already clear that large-scale use of ethanol for fuel will almost certainly require cellulosic technology.

27 JANUARY 2006 VOL 311 SCIENCE

# Conversion of energy forms



# Initial studies concluded corn ethanol emits less GHG than gasoline



Independent estimates of GHG reduction from corn ethanol

- 18% : Farrell *et al.* (2006)
- 12% : Hill *et al.* (2006)
- 19% : Wang *et al.* (2007)



# Growing concerns over biofuels



# Land use change and GHG emissions

Direct LUC

## **Land Clearing and the Biofuel Carbon Debt**

Joseph Fargione,<sup>1</sup> Jason Hill,<sup>2,3</sup> David Tilman,<sup>2\*</sup> Stephen Polasky,<sup>2,3</sup> Peter Hawthorne<sup>2</sup>

Indirect LUC

## **Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change**

Timothy Searchinger,<sup>1\*</sup> Ralph Heimlich,<sup>2</sup> R. A. Houghton,<sup>3</sup> Fengxia Dong,<sup>4</sup> Amani Elobeid,<sup>4</sup> Jacinto Fabiosa,<sup>4</sup> Simla Tokgoz,<sup>4</sup> Dermot Hayes,<sup>4</sup> Tun-Hsiang Yu<sup>4</sup>

# EISA definition of lifecycle GHG emissions

“(H) LIFECYCLE GREENHOUSE GAS EMISSIONS.—The term ‘lifecycle greenhouse gas emissions’ means the aggregate quantity of greenhouse gas emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes), as determined by the Administrator, related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gases are adjusted to account for their relative global warming potential.

Are biofuels better for society than  
the fossil fuels they displace?

# Full cost accounting

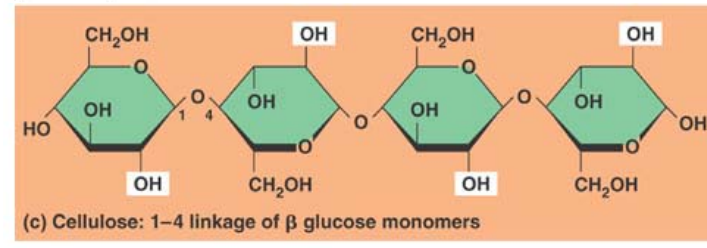
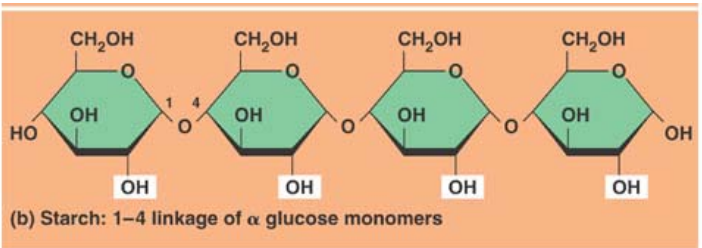
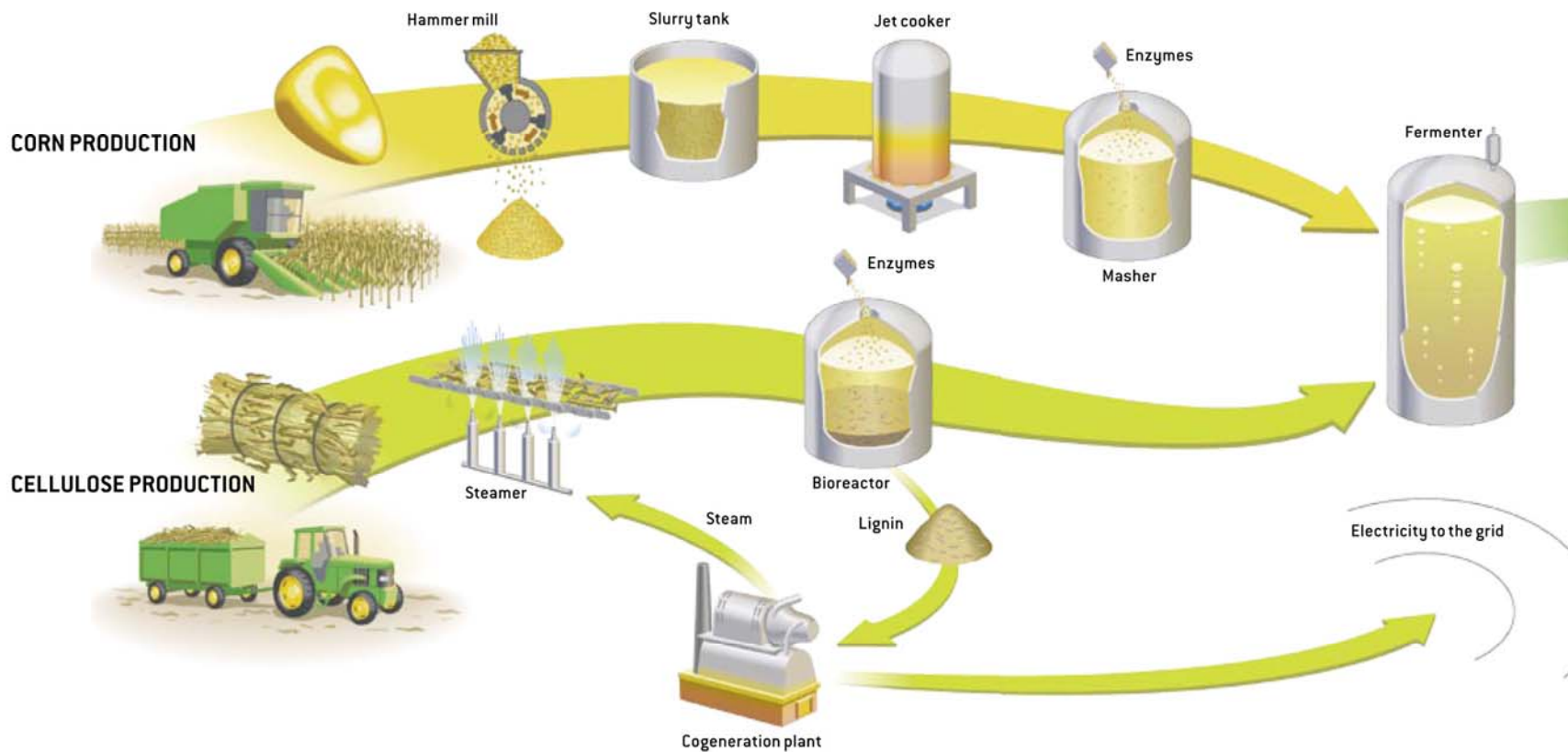
- Need for a common metric = \$
- Full cost = direct costs + external costs
- What are the external costs associated with producing and using gasoline and ethanol from different sources?
- Greenhouse gas (GHG)
- Fine particulate matter (PM<sub>2.5</sub>)
- Consider a billion gallon increase in ethanol or energy equivalent amount of gasoline

# Scenarios

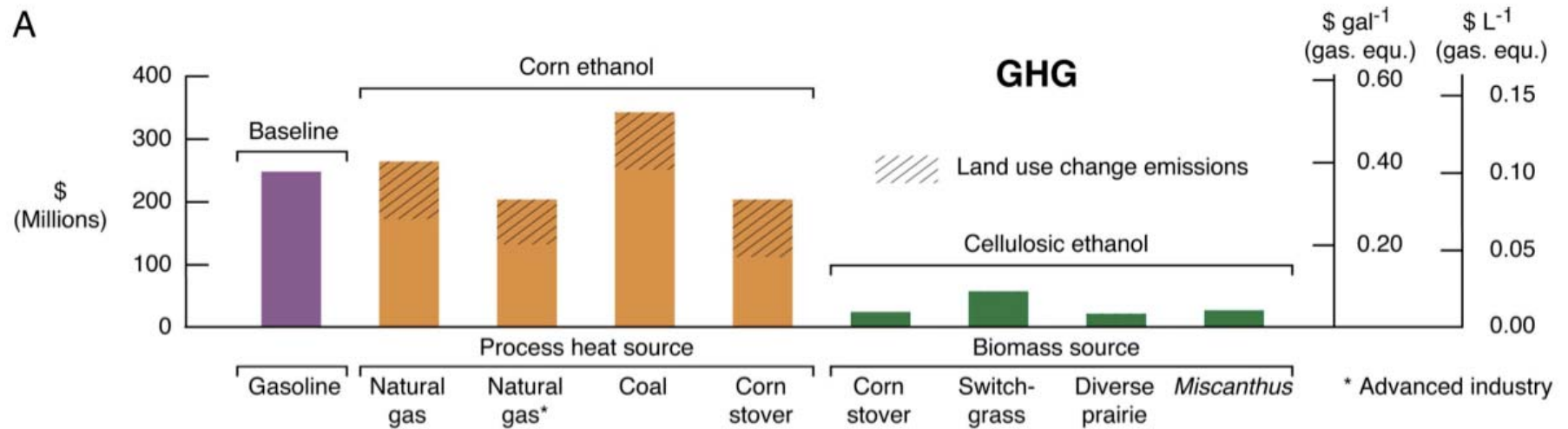
- Gasoline
- Corn ethanol
  - Natural Gas
  - Natural Gas (Advanced)
  - Coal
  - Stover
- Cellulosic ethanol
  - Corn stover
  - Switchgrass
  - Diverse prairie
  - *Miscanthus*



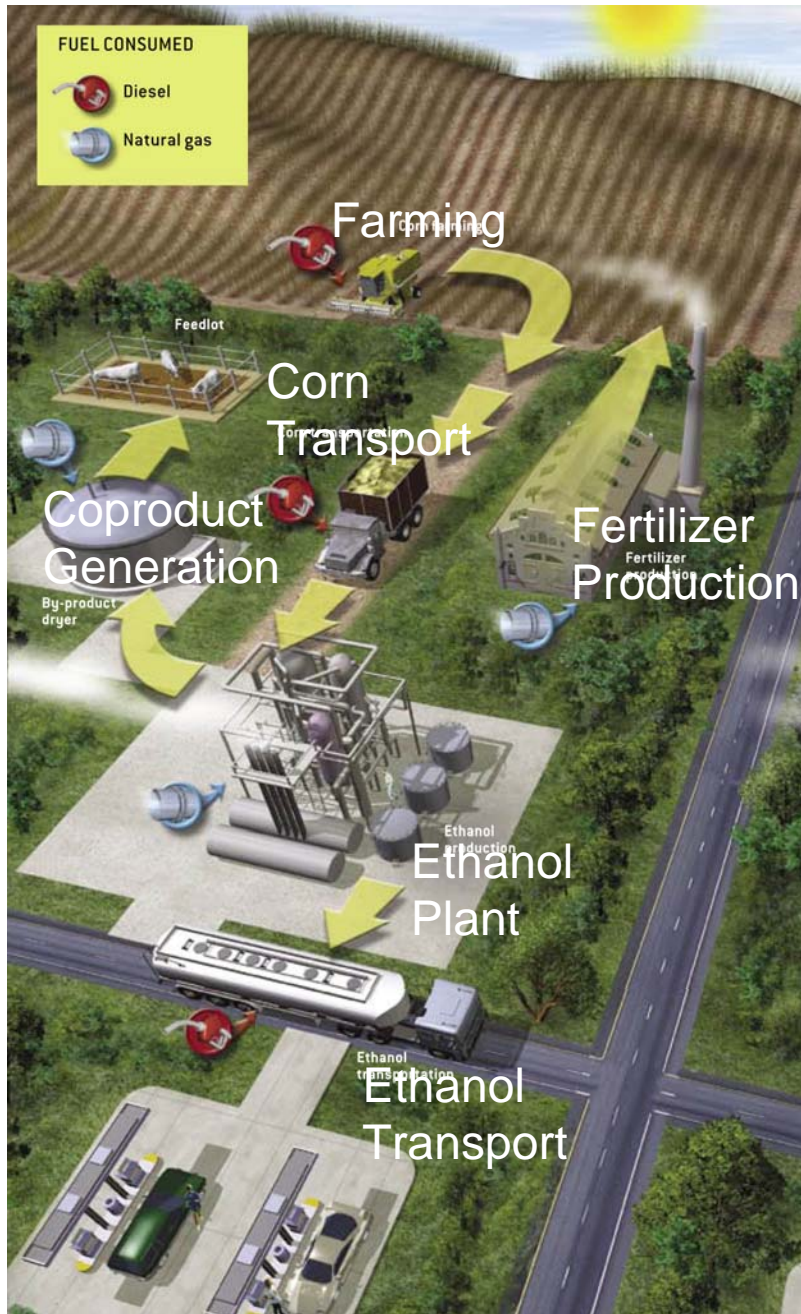
# Cellulosic ethanol production...



# External cost of GHG emissions



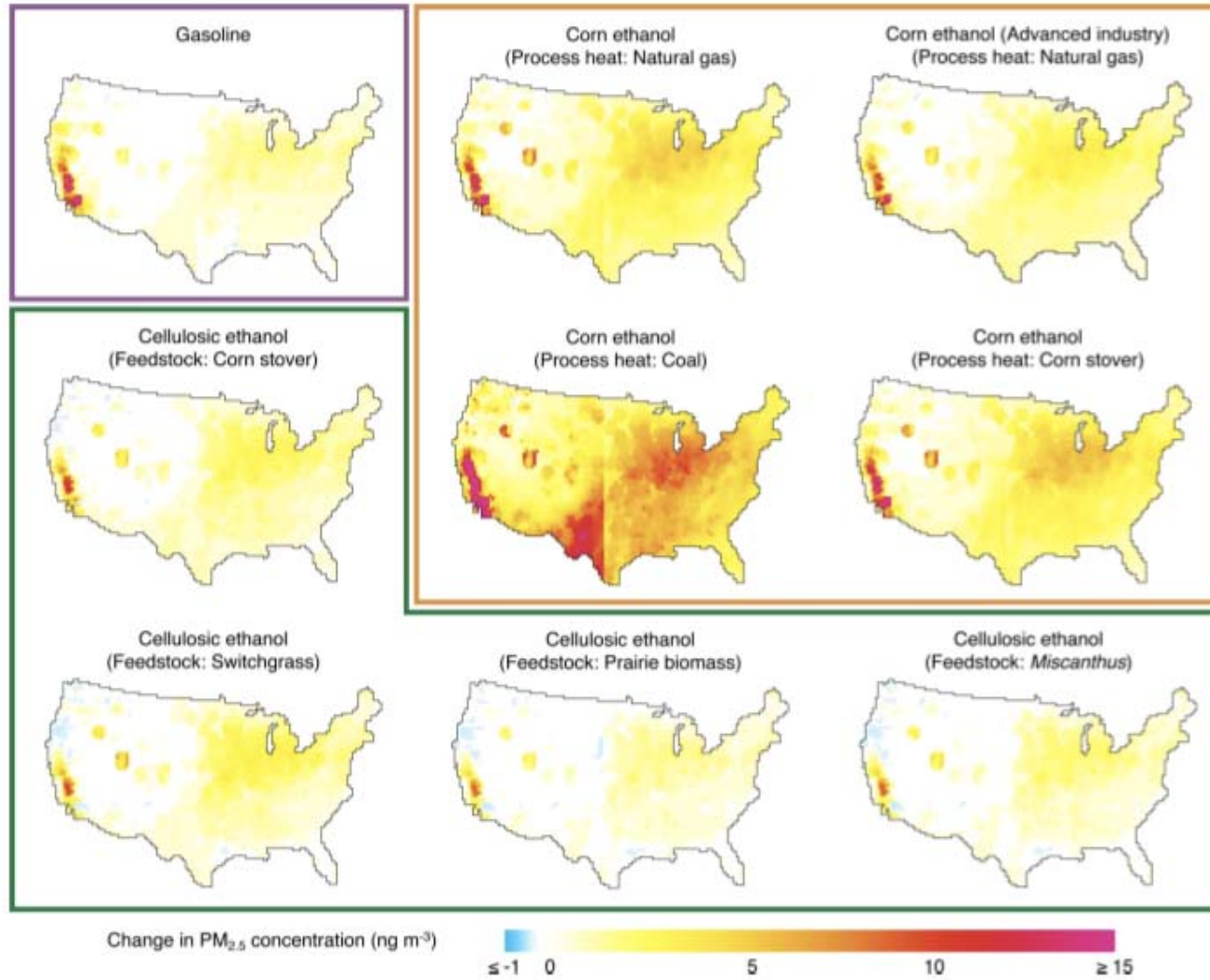
$$C = \$120 / \text{tonne}$$



# Spatial LCA

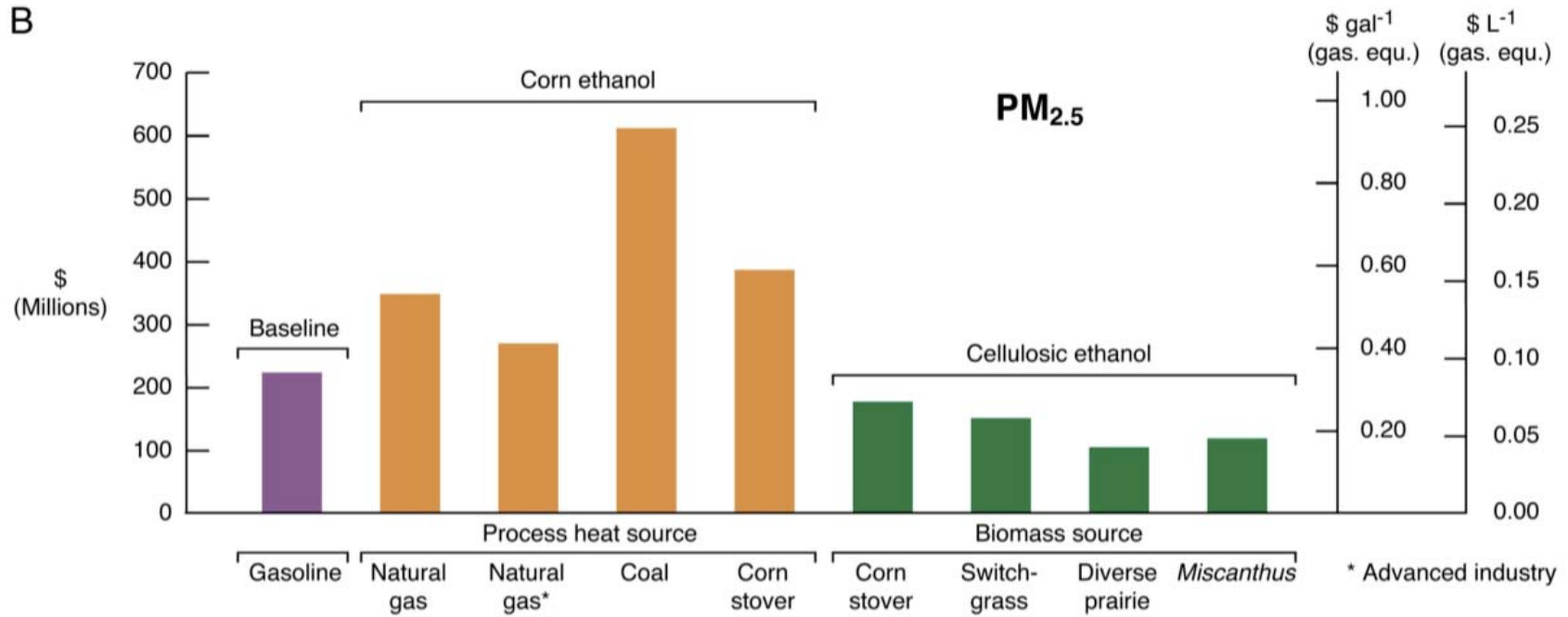
With respect to damage costs/benefits, GHG is the exception, rather than the rule.

# Air quality impacts (PM<sub>2.5</sub>)

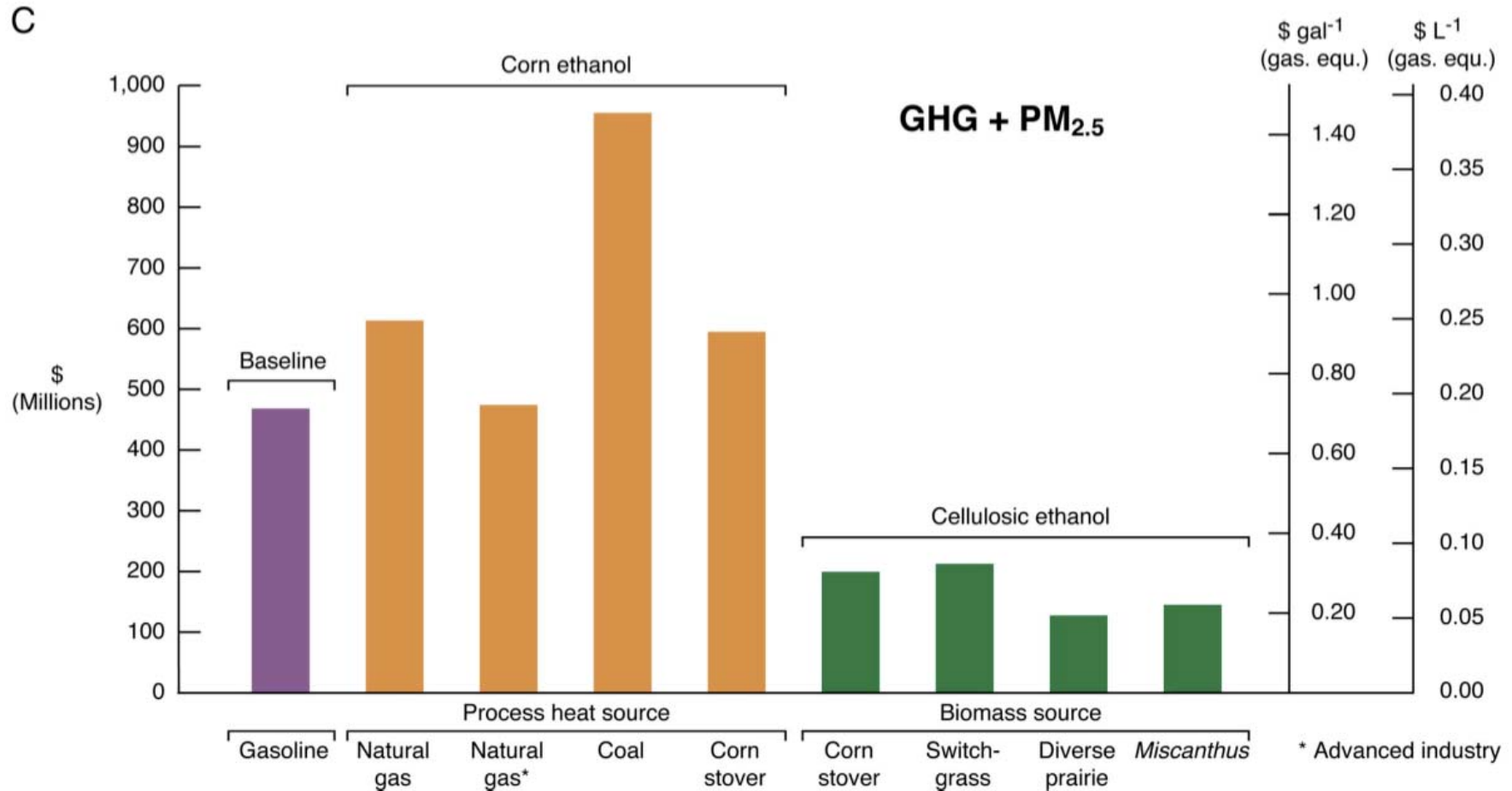


# External cost of PM<sub>2.5</sub> emissions

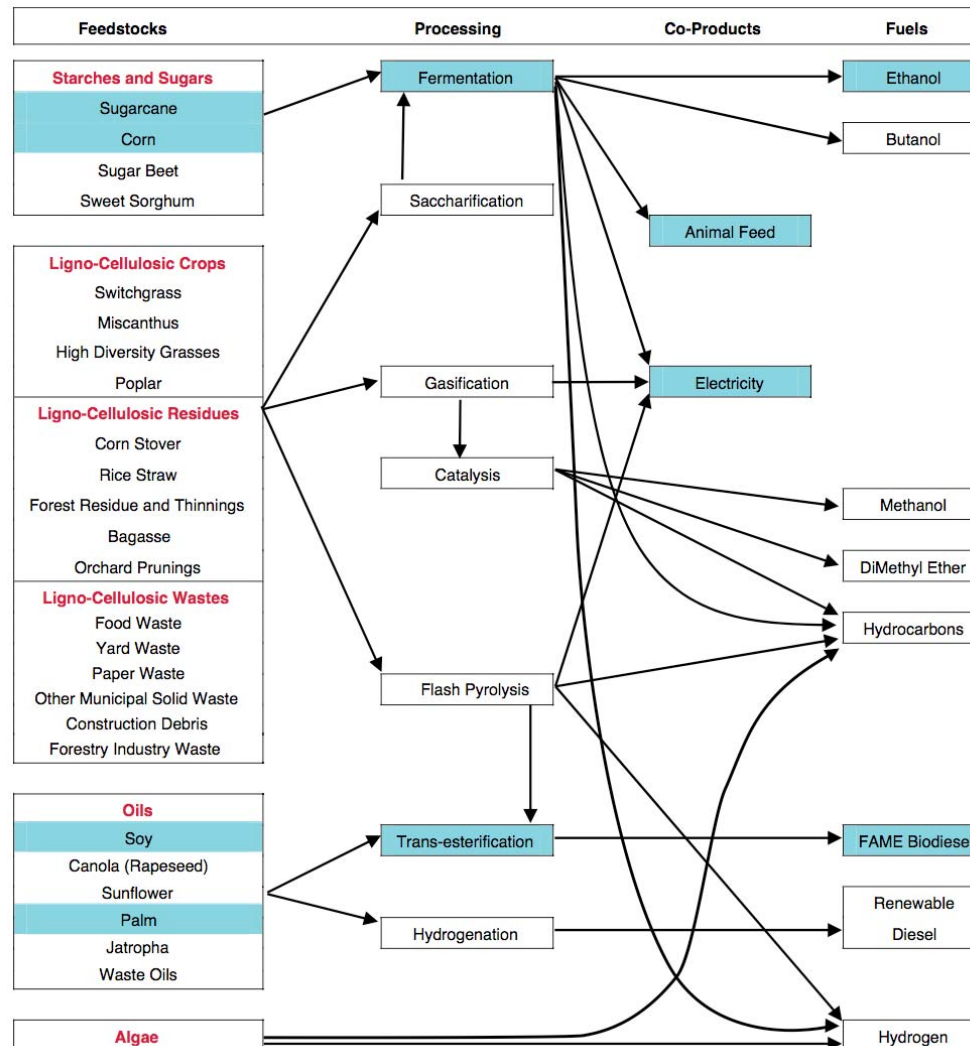
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# Combined GHG and PM<sub>2.5</sub> costs



# New biofuels from new feedstocks

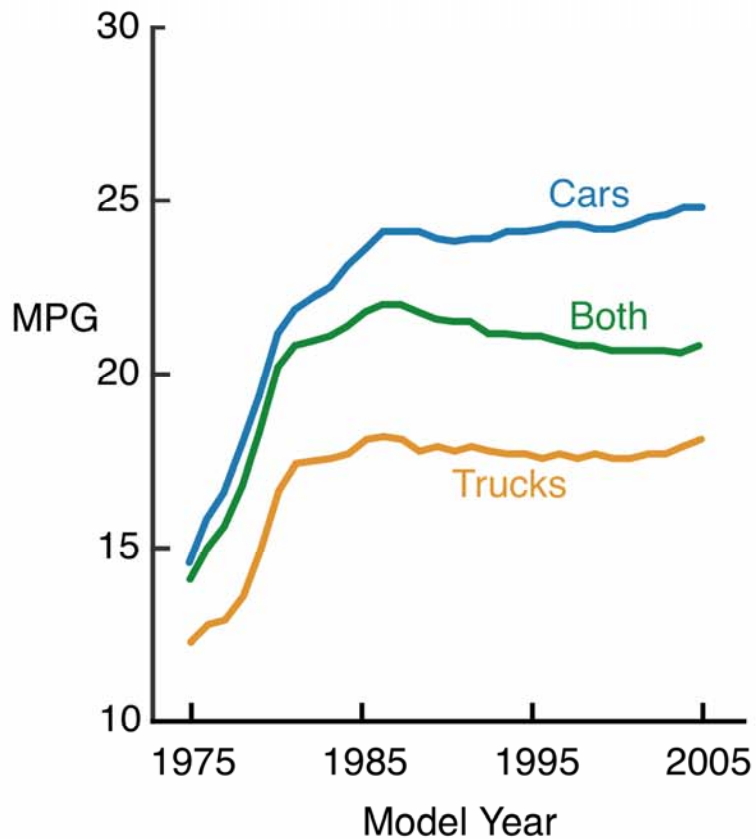


From Farrell and Gopal (2008)

Slide 21

# The low-hanging fruit

Fuel economy has not improved



Weight and performance have increased

