THE NATIONAL ACADEMIES

DIVISION ON EARTH AND LIFE STUDIES

Renewable Fuel Standard

Potential Economic and Environmental Effects of U.S. Biofuel Policy

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High uncertainty

“Yet, with all the expertise available to us, our clearest conclusion is that there is very high uncertainty in the impacts we were trying to estimate. The uncertainties include essentially all of the drivers of biofuel production and consumption, and the complex interactions among those drivers: future crude oil prices; feedstock costs and availability, technological advances in conversion efficiencies, land use change, government policy, and more.”

From the preface by Indy Burke and Wally Tyner

What is the potential biofuels production? Do we have adequate feedstocks available to meet the RFS?

Committee reviewed the following:

- Projections from the National Biorefinery Siting Model
- EPA's regulatory impact assessment
- USDA's Regional Roadmap to Meeting the Biofuels Goals of the Renewable Fuels Standard by 2020
- Report of the Biomass Research and Development Initiative
- Other estimates and models

A review of previous estimates found that the United States has the capability to produce adequate biomass feedstock for production of 16-20 billion gallons of cellulosic biofuels to meet RFS2. 500-600 million dry tons of biomass feedstock could be produced.

Uncertainties regarding feedstock production and supply:

- Competition for biomass
- Pests and diseases
- Yield increase as a result of research
- Farmers' willingness to grow and harvest feedstocks

The per-unit costs of biofuel feedstock production

Biofuel Breakeven Model used to estimate:

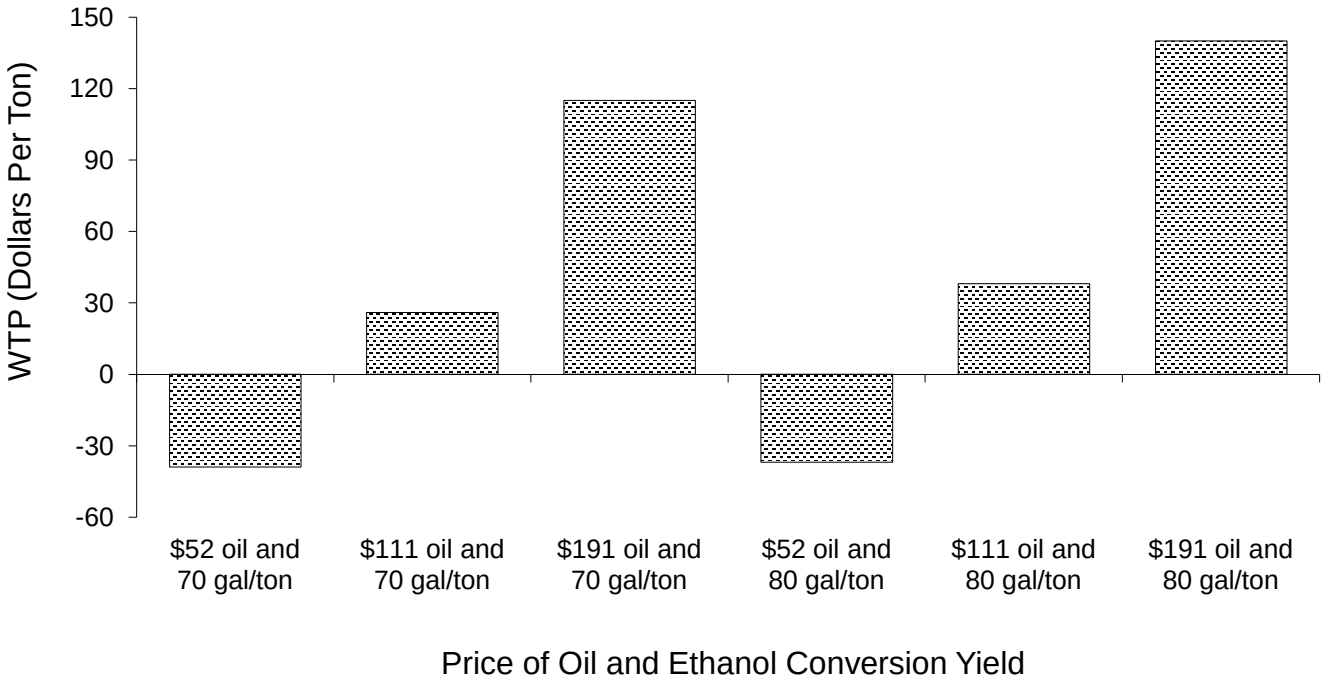
- The minimum price that biomass suppliers would be willing to accept (WTA) for a dry ton of biomass delivered to the biorefinery gate.
- The maximum price that processors would be willing to pay (WTP) to at least break even.
- Difference between the WTP and WTA calculated for three oil price projections for 2022 from DOE's Annual Energy Outlook in 2008$:
  - $52 (low)
  - $111 (reference)
  - $191 (high)

Gap between supplier's price and processor's price is negative for all types of cellulosic biomass likely to be produced in 2022.

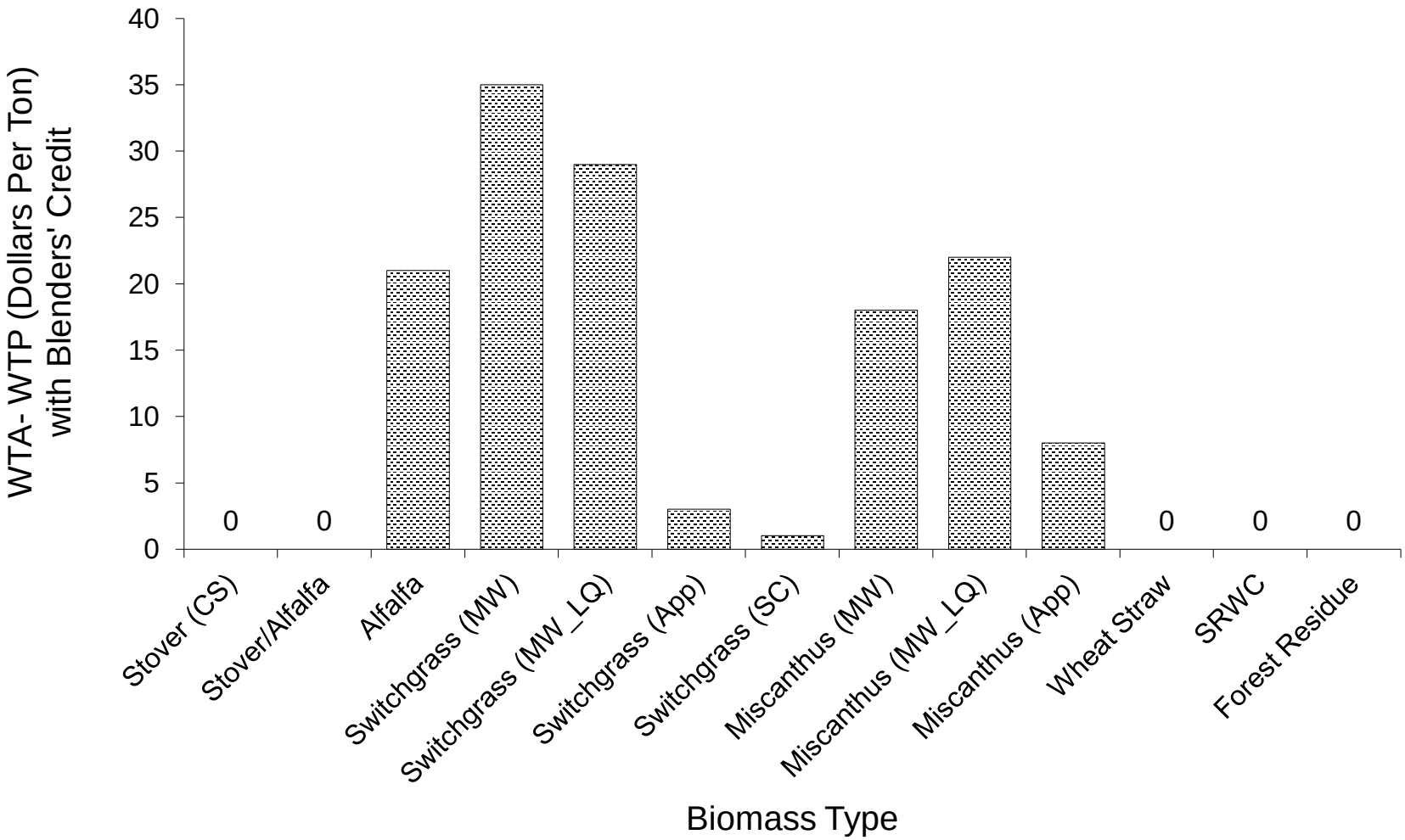
Price Gap Between Biomass Suppliers and Processors				
Cellulosic Feedstock	Supplier's Price	Processor's Price	**Price Gap (Per Dry Ton)**	Price Gap (Gallon of Ethanol)
Corn Stover in Corn-Soybean Rotation	$92	$25	**$67**	$0.96
Alfalfa	$118	$26	**$92**	$1.31
Switchgrass in the Midwest	$133	$26	**$106**	$1.51
Switchgrass in the South-central region	$98	$26	**$72**	$1.03
Short Rotation Woody Crops	$89	$24	**$65**	$0.93
Forest Residues	$78	$24	**$54**	$0.77

Source: Examples from committee analysis in BioBreak model. Price of Oil $111/barrel. Biomass yield 70 gallons of ethanol per dry ton.

Sensitivity Analysis for Oil Price and Conversion Rate



Sensitivity of WTP for switchgrass to the price of oil and ethanol conversion rate without policy incentives.

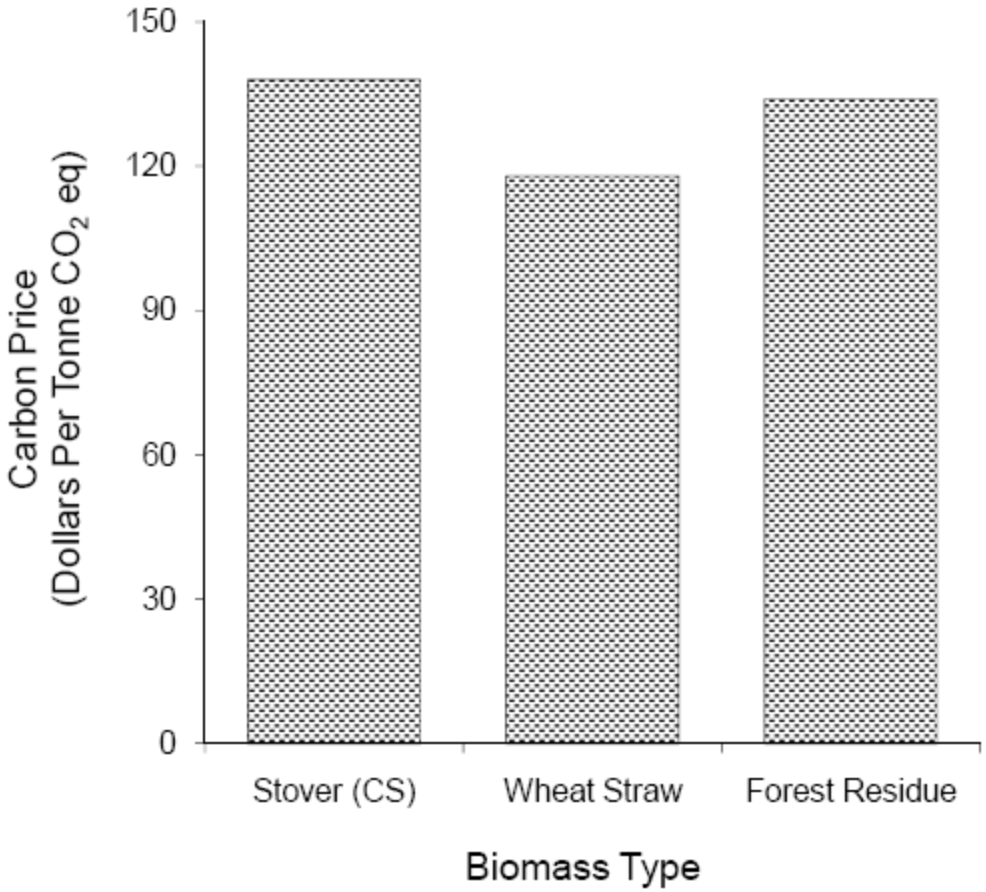


Gap between supplier WTA and processor WTP with blender's credit only projected by Biofuel Breakeven model.

NOTE: Assumptions - $111 per barrel of oil and a biomass to fuel conversion efficiency of 70 gallons per dry ton.

Breakeven Carbon Prices for Various Feedstocks

Projected carbon price needed for feedstock market ($ per metric ton)



FINDING: Only in an economic environment characterized by high oil prices, technological breakthroughs, and a high implicit or actual carbon price would biofuels be cost-competitive with petroleum-based fuels.

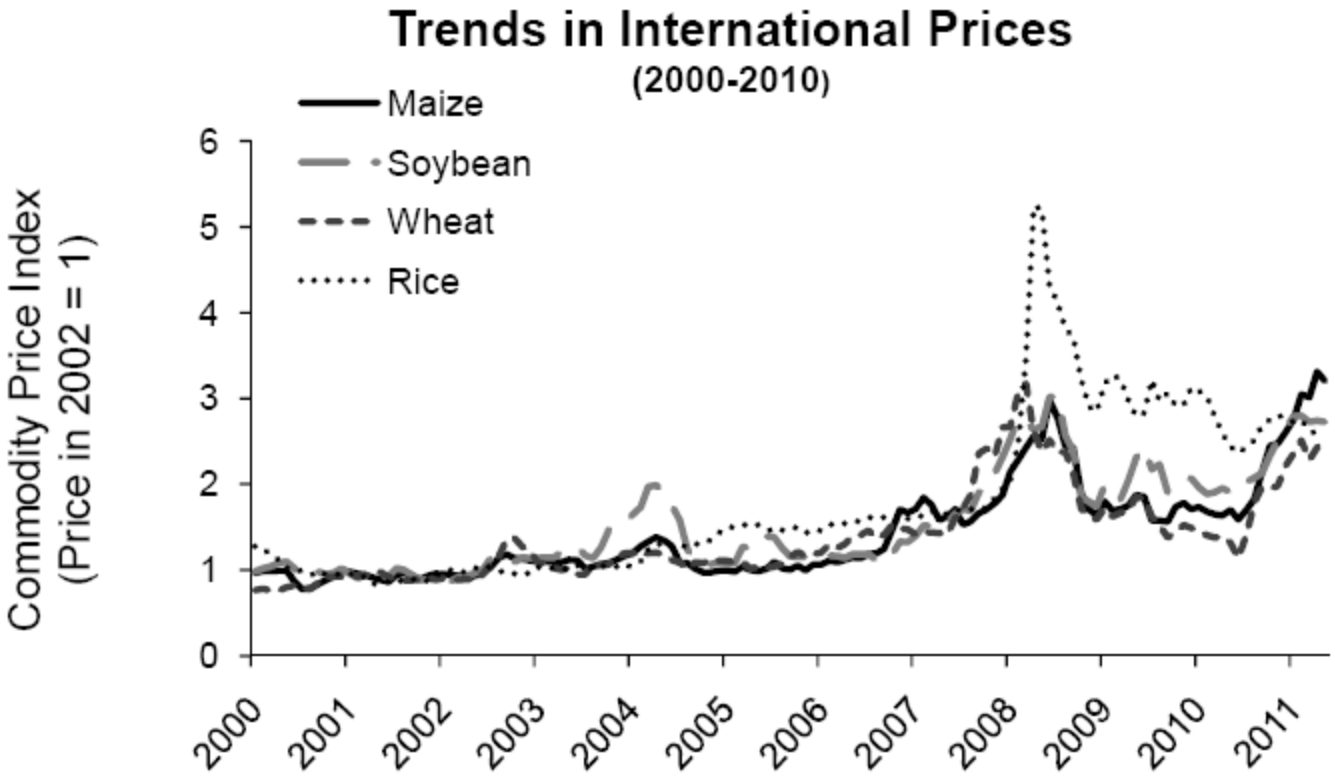
Finding: RFS2 cellulosic fuel mandate unlikely to be met in 2022

- Aggressive deployment, in which the capacity build rate more than doubles the historic capacity build rate of corn-grain ethanol, is necessary to produce 16 billion gallons of cellulosic biofuels by 2022.
- Policy uncertainties could deter investors from aggressive deployment.

- Price gap for cellulosic feedstock could be closed under other market circumstances:
  - Price of oil reaches $191 per barrel.
  - A price is placed on carbon that makes cellulosic biofuels more cost-competitive.
  - Government subsidy payments increase to cover price gap.
  - Government biofuel mandates are enforced.

FINDING: Absent major increases in agricultural yields and improvement in the efficiency of converting biomass to fuels, additional cropland will be required for cellulosic feedstock production; thus, implementation of RFS2 is expected to create competition among different land uses, raise cropland prices, and increase the cost of food and feed production.

Many Factors Have Led to the Agricultural Commodity Price Increases – Including Biofuels



Agricultural commodity prices increased 20-40% in 2007-2009.

- Retail prices less affected by market swings because primary crops used for biofuels typically highly processed for food production.
- Livestock market affected more because it uses raw commodities.
  - Increased cost of production
  - Some competition reduced by use of DDGS.

Wood product prices will experience upward pressure if cellulosic biofuels are commercially produced.

FINDING: Food-based biofuel is one of many factors that contributed to upward price pressure on agricultural commodities, food, and livestock feed since 2007.

Other factors affecting those prices included growing population and incomes overseas, crop failure in other countries, high oil prices, decline in the value of the U.S. dollar, and speculative activity in the marketplace.

FINDING: Key barriers to achieving RFS2 are the high cost of producing cellulosic biofuels compared to petroleum-based fuels and uncertainties in future biofuel markets.

An analysis of the effect of current and projected future levels of biofuels production and use on the environment (Chapter 5)

Environmental effects assessed:

- Greenhouse gas emissions
- Air quality
- Water quality
- Consumptive water use
- Soil quality
- Biodiversity

An analysis of the effect of current and projected future levels of biofuels production and use on the environment (Chapter 5)

Environmental effects depend on:

- feedstock type,
- site-specific factors,
- feedstock production management practices,
- land condition prior to feedstock production, and
- conversion yield.

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The committee concluded that:

- Biofuel production could result in positive, neutral or negative environmental outcomes.
- Whether RFS2 provides net environmental benefits cannot be answered at this time.

An analysis of the effect of current and projected future levels of biofuels production and use on the environment (Chapter 5)

The effects of RFS2 are uncertain because:

- How and where biomass feedstocks will be grown, and how they will be converted to biofuels and used, are unknown and not predictable.
- Complete assessments of the environmental outcomes of substituting conventional fuels with RFS2-mandated biofuels have not been conducted.

An analysis of the effect of current and projected future levels of biofuels production and use on the environment (Chapter 5)

Greenhouse gas emissions are affected by:

- Feedstock type
- Previous land-use
- Nutrient management practices
- Market-mediated effects

An analysis of the effect of current and projected future levels of biofuels production and use on the environment (Chapter 5)

TABLE 5-3 Published Estimates of and Some Assumptions Used in Estimating Life-Cycle Greenhouse-Gas (GHG) Emissions of Corn-Grain Ethanol

Life-cycle GHG (g CO_2 eq per MJ)	Region for which the estimate was made	Indirect land-use change included	Reference
77	U.S. average	No	Farrell et al. (2006)
85	U.S. average	No	Hill et al. (2006)
177	U.S. average	Yes	Searchinger et al. (2008)
52	Individual facility in the Midwest	No	Bremer et al. (2010)
104	U.S. average	Yes	Hertel et al. (2010)
101	U.S. average	Yes	Mullins et al. (2010)
69	U.S. average	Yes	Wang et al. (2011a)

NOTE: None of the studies listed in this table estimated specifically the extent to which volumes of corn-grain ethanol produced to meet the RFS2 consumption mandate would change GHG emissions.

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General trends for GHG emissions include:

- Food based biofuels such as corn-grain ethanol have not been conclusively shown to reduce GHG emissions and may actually increase them
- Biofuels from agricultural and forestry residues and municipal solid wastes are most likely to reduce GHG emissions
- Biofuels from bioenergy crops like switchgrass may either reduce or increase GHG emissions depending on how and where biomass is grown

An analysis of the effect of current and projected future levels of biofuels production and use on the environment (Chapter 5)

Finding:

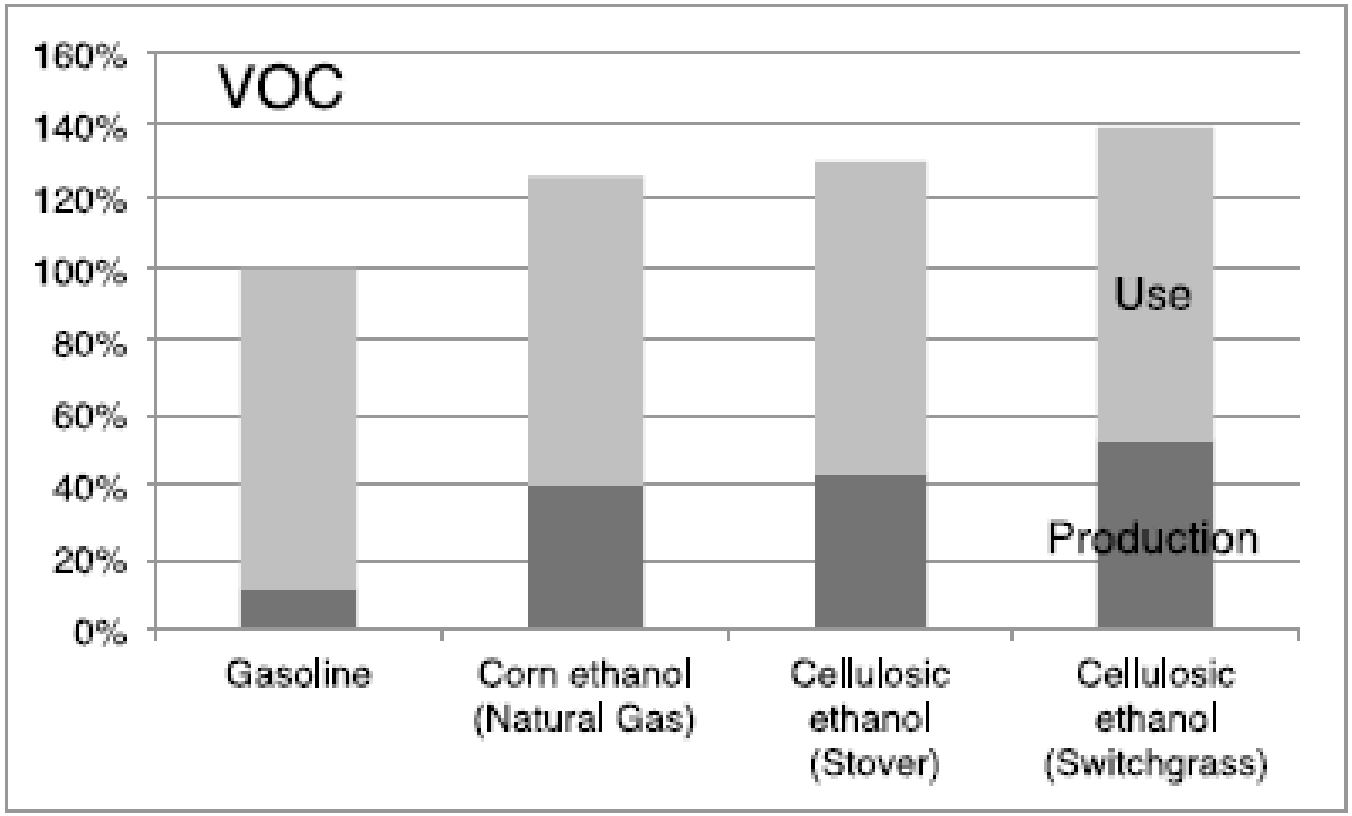
RFS2 may be an ineffective policy for reducing global GHG emissions because the effect of biofuels on GHG emissions depends on how the biofuels are produced and what land-use or land-cover changes occur in the process.

An analysis of the effect of current and projected future levels of biofuels production and use on the environment (Chapter 5)

General trends for air quality include:

- Current focus on tailpipe emissions is misguided and misses majority of emissions of pollutants affecting air quality over the fuels' life cycle.
- Overall production and use of ethanol will result in higher pollutant concentrations for ozone and particulate matter than their gasoline counterparts on a national average.
- Local effects could be variable, necessitating modeling approaches that account for variability.

An analysis of the effect of current and projected future levels of biofuels production and use on the environment (Chapter 5)



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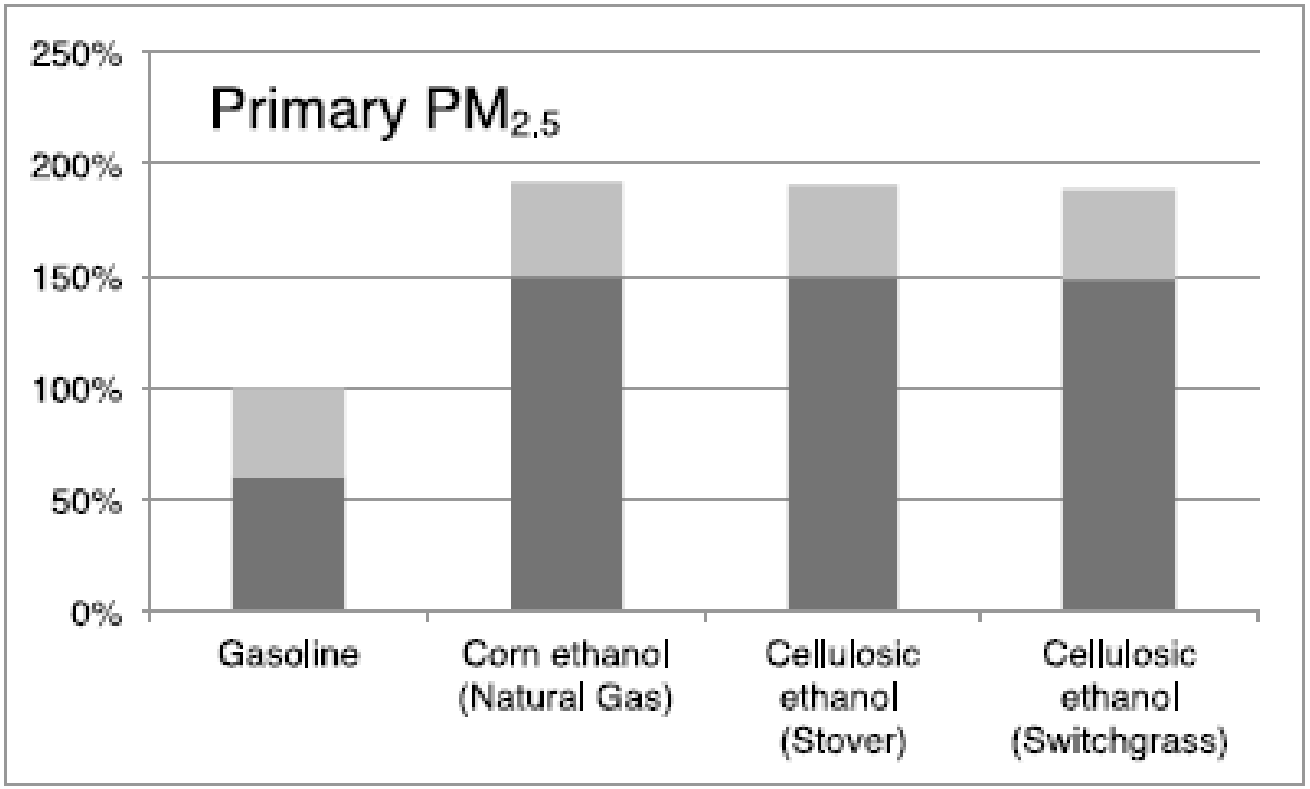

An analysis of the effect of current and projected future levels of biofuels production and use on the environment (Chapter 5)

General trends for water consumptive use include:

- Consumptive water use over the life cycle is higher for corn-grain ethanol than conventional fuels even if biofuels are from non-irrigated crops.
- If switchgrass is grown without irrigation and converted using a thermochemical process, consumptive water use may be comparable to conventional fuels.
- Whether higher life cycle consumptive use is an environmental problem is regionally dependent.

An analysis of the effect of current and projected future levels of biofuels production and use on the environment (Chapter 5)

General trends for soil quality and biodiversity include:

- Soil quality and biodiversity may be improved or degraded depending on feedstock grown, prior condition of land, and management practices used.
- Effects of increasing biofuel production on soil quality and biodiversity cannot be generalized.

Thank you. Report is available online at www.nap.edu.