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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Statement of Task

- Describe biofuels produced in 2010 and projected to be produced and consumed by 2022 using RFS-compliant feedstocks primarily from U.S. forests and farmland.
- Review model projections and other estimates of the relative effects of increasing biofuels production as a result of RFS2 on the prices of:
  - Land, food, feed, and forest products.
  - Imports and exports of relevant commodities.
  - Federal revenue and spending.
- Discuss the potential environmental harm and benefits of biofuels production and the barriers to achieving the RFS2 consumption mandate.

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."

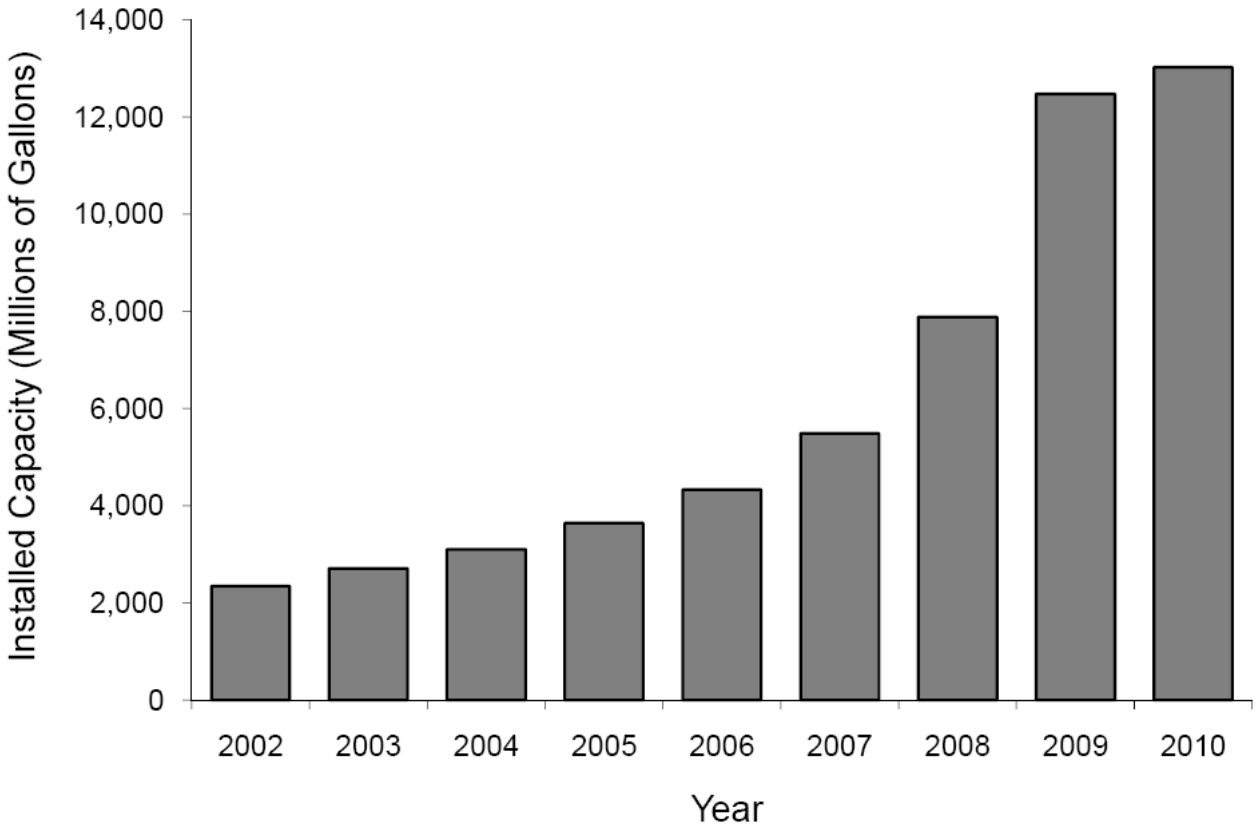
From the preface by Indy Burke and Wally Tyner

Task: A quantitative and qualitative description of biofuels currently produced (Chapter 2)

Types of Biofuels (not necessarily produced at commercial scale)

- **Food-based biofuels**
  - Corn-grain ethanol
  - Biodiesel from vegetable oils and animal fats
- **Non-food based biofuels**
  - Cellulosic biofuels
    - Agricultural residues
    - Dedicated bioenergy crops
    - Forest resources
    - Municipal solid wastes
- **Other biofuels in development**

Task: A quantitative and qualitative description of biofuels currently produced (Chapter 2)



Installed capacity of all ethanol biorefineries in the United States combined from January 2002 to January 2010.

Task: A qualitative and quantitative description of biofuels that could be produced in different regions of the United States, including a review of estimates of potential biofuel production levels using RFS-compliant feedstocks from U.S. forests and farmland (Chapter 3)

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

Task: Estimate the per-unit costs of biofuel feedstock production (Chapter 4)

Biofuel Breakeven Model used to estimate:

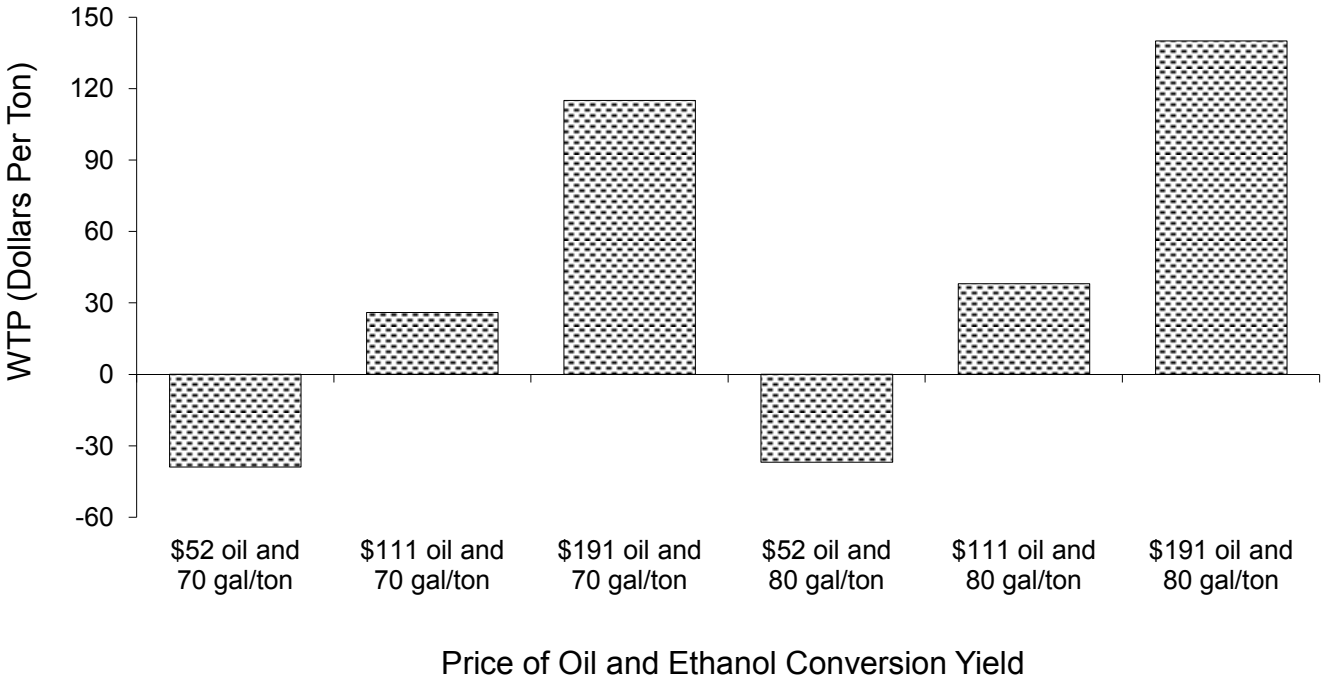
- The minimum price that biomass suppliers would be willing to accept (WTA) for a dry ton of biomass delivered to the biorefinery gate.
- The maximum price that processors would be willing to pay (WTP) to at least break even.
- Difference between the WTP and WTA calculated for three oil price projections 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.

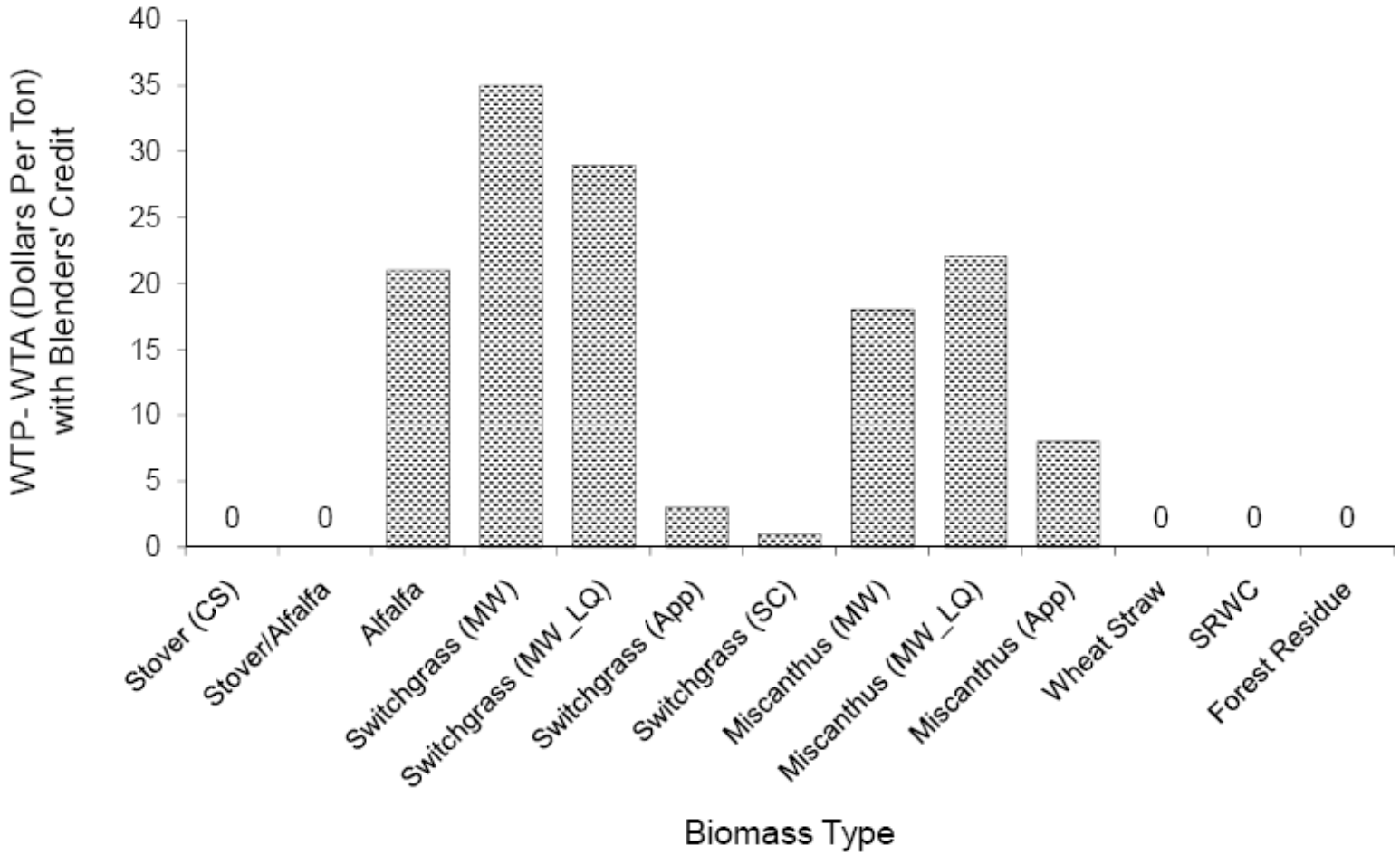
Price Gap Between Biomass Suppliers and Processors				
Cellulosic Feedstock	Supplier's Price	Processor's Price	**Price Gap (Per Dry Ton)**	Price Gap (Gallon of Ethanol)
Corn Stover in Corn-Soybean Rotation	$92	$25	**$67**	$0.96
Alfalfa	$118	$26	**$92**	$1.31
Switchgrass in the Midwest	$133	$26	**$106**	$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.

Task: A quantitative description of biofuels projected to be produced and consumed by 2022 in the United States under different policy scenarios (Chapter 4)



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

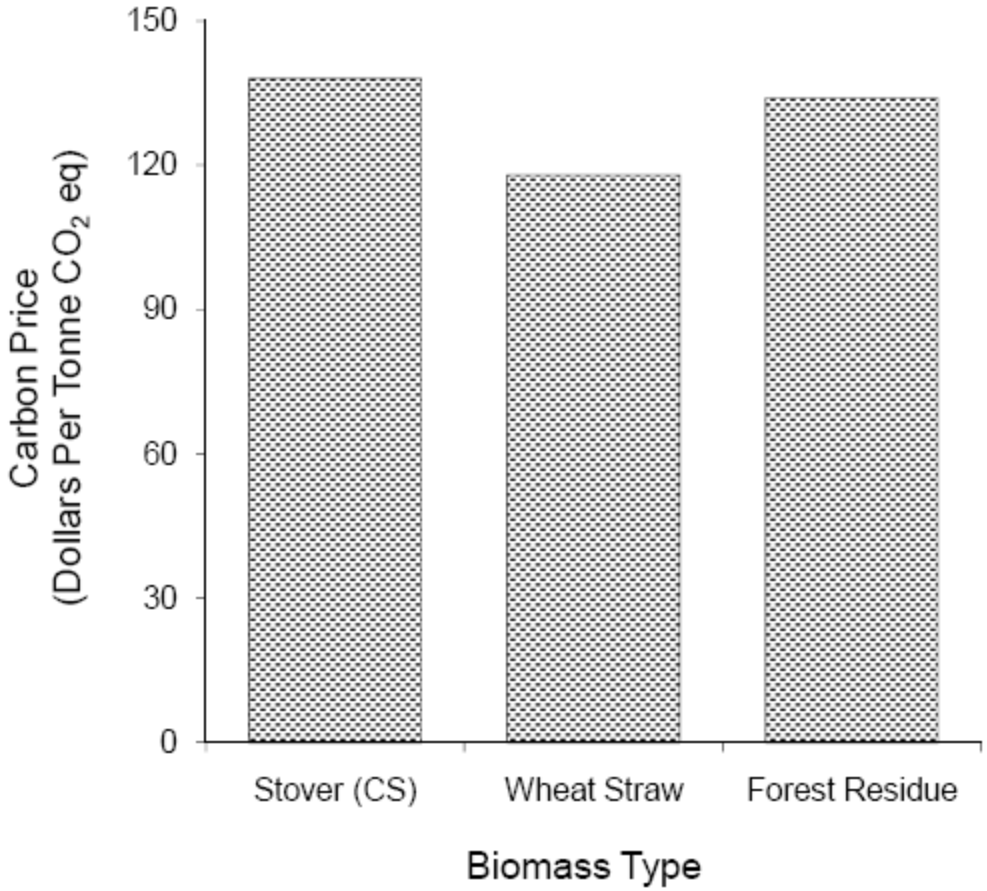


Gap between supplier WTA and processor WTP with blender's credit only projected by BioBreak model.

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

Task: A quantitative description of biofuels projected to be produced and consumed by 2022 in the United States considering the effect of a carbon price (Chapter 4)

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

- No commercially viable biorefineries exist, to date, for converting lignocellulosic biomass to fuels.
- Aggressive deployment, in which the capacity build rate more than doubles the historic capacity build rate of corn-grain ethanol, necessary to produce 16 billion gallons of cellulosic biofuels by 2022.
- Policy uncertainties could deter investors from aggressive deployment.

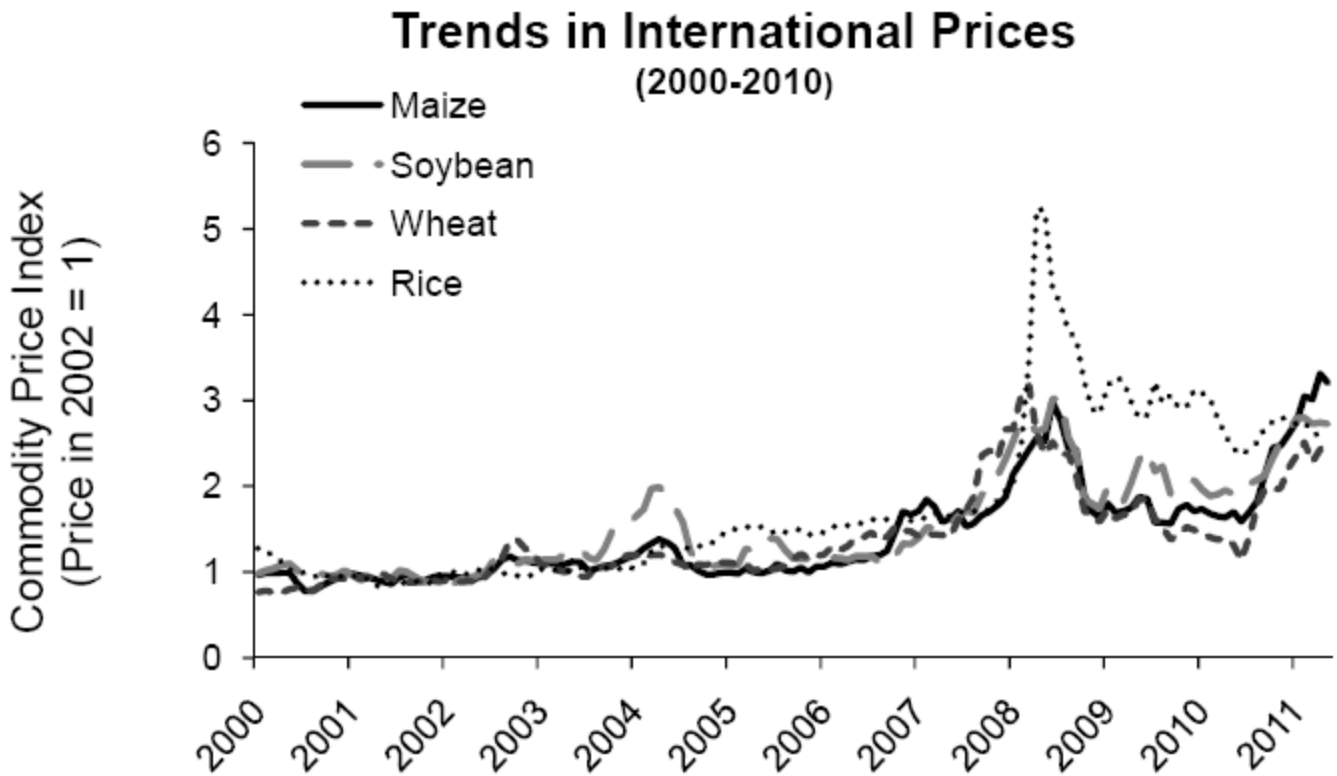
- Price gap for cellulosic feedstock could be closed under other market circumstances:
  - Price of oil reaches $191 per barrel.
  - A price is placed on carbon that makes cellulosic biofuels more cost-competitive.
  - Government subsidy payments increase to cover price gap.
  - Government biofuel mandates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

Task: An assessment of the effects of current and projected levels of biofuel production on the number of U.S. acres used for crops, forestry, and other uses, and the associated changes in the price of rural and suburban land (Chapter 4)

- Producing 16 billion gallons of ethanol-equivalent cellulosic biofuels by 2022 might create competition among land uses.
- Land prices will increase because of increased demand for food and feedstock production.
  - Direct demand factor - a potential increase in land used for dedicated biofuel crops.
  - Indirect demand factor - new demand for surplus agricultural residue would increase the overall value of land.

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.

Task: An analysis of the pros and cons of achieving legislated RFS levels on the prices of animal feed, food grains, and forest products (Chapter 4)



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.

Task: An analysis of the effects of current and projected levels of biofuel production on U.S. exports and imports (Chapter 4)

- Exports of corn, soybean, and wheat held steady largely due to a huge decline in the value of the U.S. dollar between 2002 and 2008.
- RFS2 and EU biofuel mandates result in increased animal product cost and decrease the global value of livestock industries.
- RFS2 mandate will likely increase wood imports into the United States.
- Little effects on import of petroleum-based fuels.

Task: A review of estimates of the relative effects of the RFS, biofuel tax and tariff policy, production costs, and other factors on biofuel and petroleum refining capacity, and on the types, amounts, and prices of biofuel feedstocks, biofuels, and petroleum-based fuels (including finished motor fuels) produced and consumed in the United States (Chapter 4)

- Biofuel refining capacity limited by the capacity for producing cellulosic ethanol.
- RFS2 could influence feedstock producers and investors' decision-making. High cost of production and market uncertainties deter private investment.
- RFS uncertainty for cellulosic biofuels impediment to investment.

Task: An analysis of the effect of projected biofuel production on federal revenue and spending (Chapter 4)

- Agricultural commodity payments – not expected to change.
- Conservation Reserve Program (CRP)
  - Cost increase if per-acre payment levels are increased to incentivize producers to keep the most sensitive land in the program.
  - Cost decrease if withdrawn CRP acreage is not replaced.
- Grants, loans, and loan guarantees (Table 4-6).
- Forgone revenue from biofuels subsidies far exceeds any potential savings from CRP.

FINDING: Achieving RFS2 would increase the federal budget outlays mostly as a result of increased spending on payments, grants, loans, and loan guarantees to support the development of cellulosic biofuels and foregone revenue as a result of biofuel tax credits.

Task: 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
- Effects on soil carbon
- Biodiversity

Environmental Effects of Producing Biofuels to Meet RFS2

- Environmental effects depend on
  - feedstock type,
  - site-specific factors,
  - feedstock production management practices,
  - land condition prior to feedstock production, and
  - conversion yield.
- Effects of increasing biofuel production on air quality, water quality, water quantity and consumptive use, soil, and biodiversity
  - are uncertain and
  - can be local, regional, or global

Greenhouse-gas emissions

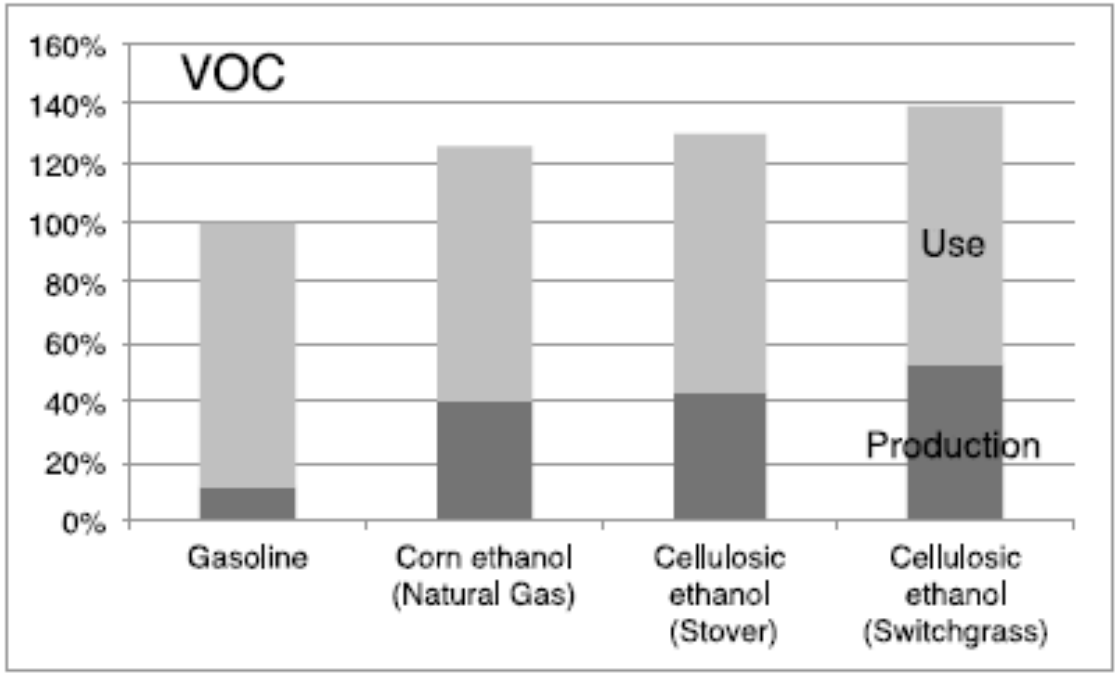
Many factors, including feedstock type, management practices, and land-use and land-cover changes influence GHG emissions. For example,

- Feedstock type affects fertilizer input needed and carbon storage in soil.
- Nutrient management practices affect fertilizer input and denitrification.
- Displacement of other crops by bioenergy feedstocks could lead to market-mediated land-use changes, resulting in changes in GHG emissions.
- Biofuels produced from residues or waste products are less likely to contribute to GHG emissions from land-use or land-cover changes.

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.

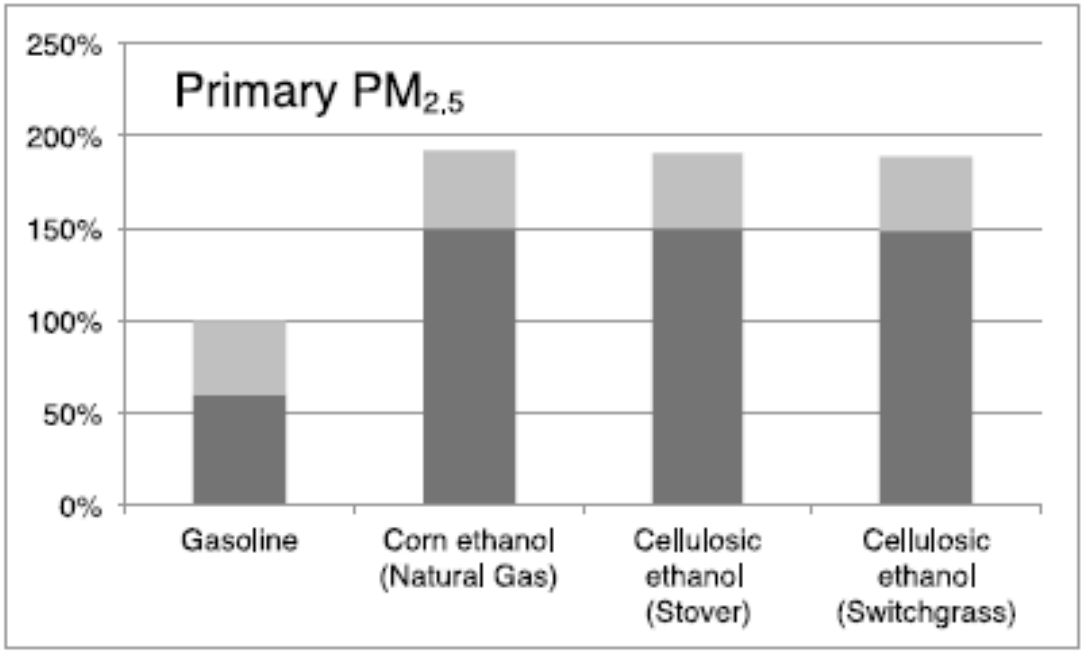
Air Quality

Overall production and use of ethanol will result in higher pollutant concentration for ozone and particulate matter than their gasoline counterparts on a national average.



Air Quality

Similar analysis done for NO_x, SO_x, and NH_3



Water Quality

- The increase in corn production has contributed to environmental effects on surface and ground water.
- Perennial and short-rotation woody crops for cellulosic feedstocks with low agrichemical inputs and high nutrient uptake efficiency hold promise for improving water quality under RFS2.
- Use of residues is not likely to incur much negative effects on water quality as long as enough residues are left in field to prevent soil erosion.

Soil and Biodiversity Effects

- Effects on soil and biodiversity can be positive or negative depending on feedstock type and management practices used.
- Effects of achieving RFS2 on soil and biodiversity currently cannot be readily quantified or qualified largely because of the uncertainty in the future.

Task: An analysis of barriers to achieving the RFS requirements (Chapter 6)

Economic barriers – ones that maintain the unsubsidized price of biofuels above the price of gasoline.

Environmental barriers – for example, resource limitations or practices or environmental discharges that violate environmental regulations.

Policy barriers – ones that could stifle the development of cellulosic biofuels industry.

Social barriers – potential producers' and consumers' perception of, attitude toward, and acceptance of biofuels.

Key barriers to achieving RFS2

- High cost of producing cellulosic biofuels compared to petroleum-based fuels.
- Uncertainties related to market conditions and government support programs (for example, EPA waiver).
- Blend wall and transportation infrastructure if large amount of biofuels for meeting RFS2 is met by ethanol

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.

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

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