# Implications of the Renewable Fuel Standard on Upper-Midwest Land Use

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## Sustainable Energy Challenges

A renewable energy supply is a key component of a more sustainable energy infrastructure; and of great interest to scientists, engineers, and policy makers alike. Cellulosic biomass can play an important role in our future energy supply – especially as a feedstock for liquid transportation fuels – but biomass also provides many important ecosystem functions. In order to utilize biomass sustainably it is important that both good science and good policy be applied effectively. In this study we investigate how Life Cycle Assessment (LCA) can work with public policies, such as the Renewable Fuel Standard (RFS) of the Energy Independence and Security Act of 2007 in order to benefit society. Here we present the results of an original LCA performed on cellulosic ethanol produced from several regionally important feedstocks. Evaluation metrics for the LCA are derived from the requirements mandated by the RFS. Additionally, an evaluation of the RFS policy is made with respect to good LCA practices to make recommendations for future policy modifications.

## Renewable Fuel Standard

- Mandates amount of ethanol to be blended into U.S. gasoline supply
- Production pathway requires greenhouse gas (GHG) reduction targets and measures of environmental quality

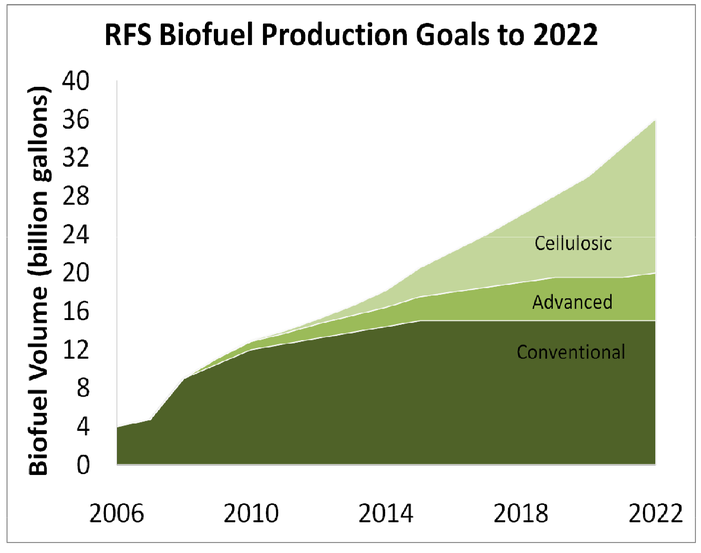
**Table 1:** RFS requirements, 36 billion gallons of ethanol by 2022

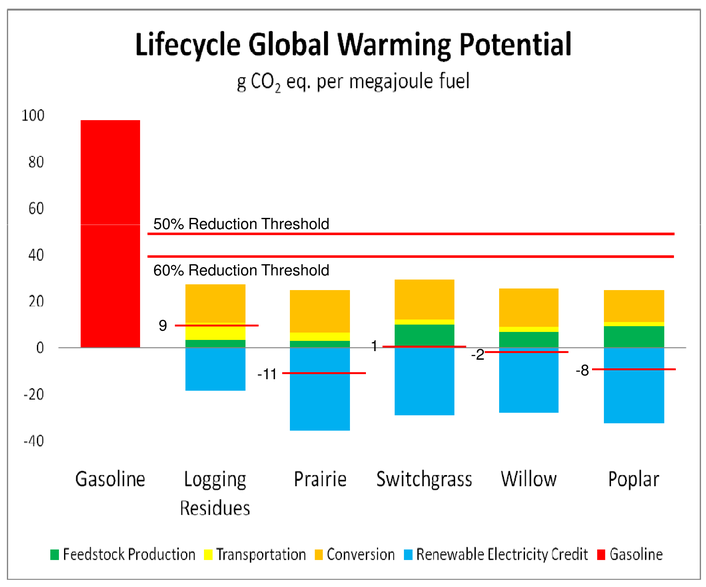
| Biofuel Type | GHG Reductions | Amount (Billion Gallons) |
|---|---|---|
| Conventional (corn starch) | 20% | 15 (capped) |
| Cellulosic | 60% | 16 (by 2022) |
| Advanced | 50% | 5 (by 2022) |

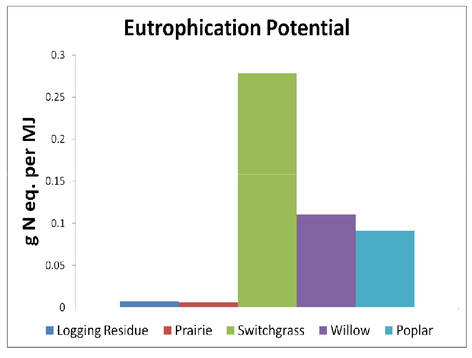
- Cellulosic ethanol production will increase once the limit of corn ethanol is reached (see top graph)
- LCA evaluation requirements from RFS:
  - Account for direct and indirect land use change GHG emissions
  - Include environmental metrics for air quality, water quality and quantity, wetlands use, ecosystem health, and wildlife habitat
  - Evaluate social metrics for energy security, commercial fuel production and infrastructure, consumer fuel prices, job creation, agricultural impacts, rural economic benefit, future food prices

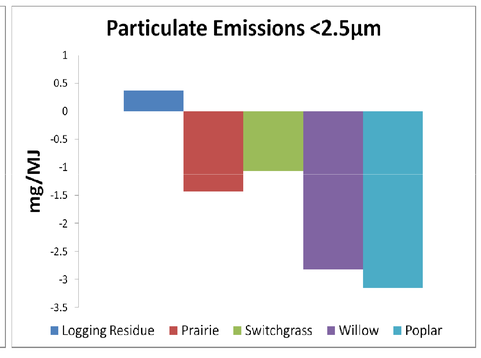
## Life Cycle Assessment

- **Screening LCA for several regionally important feedstocks:**
  - Logging residues, diverse prairie grass, switchgrass, hybrid willow, and hybrid poplar
- **Metrics derived from the requirements of RFS**
  - Global warming potential (GHG), air quality (particulate matter), and water quality (eutrophication potential)
- SimaPro 7.2 used for LCA with the EcoInvent database
- System expansion for renewable electricity co-product credit – displaces electricity from grid which is 70% coal-fired power plants




## LCA Results

- All fuel pathways analyzed meet RFS GHG reduction requirements for cellulosic biofuel (see middle graph)
  - With co-product credit, some pathways result in negative carbon emissions due to coal displacement – very good regionally!
- Eutrophication potential increased for all feedstocks due to feedstock production activities
  - Highest for switchgrass, most fertilizer intensive!
- Particulate matter emissions reduced due to avoided coal power
  - Exception: logging residues – low productivity and associated long transportation distances

## Policy Implications

- Cellulosic ethanol is technologically feasible, but good policy can help speed commercialization

**Is the RFS good policy?**

- *Yes!* Embodies good LCA practices, uses multiple metrics to ensure no unexpected environmental burdens while reducing greenhouse gas emissions
- *Maybe?* Inclusion of indirect land use change and social metrics, while necessary, increases LCA complexity and possibly compromises prediction accuracy
  - Important -- government policies affect entire economy
  - Difficult – world economic models complicated, unnecessary for most individual LCAs
  - Pushes the limit of what can be determined quantitatively and predicted accurately
- *No.* Definition of renewable feedstock excludes nearly all biomass derived from federal lands while allowing nearly any biomass from private lands
  - Should be based on sustainable land management practices rather than on public/private land ownership division

## Continuing Work

- Determine land use change carbon debt for different scenarios
- Further refine emissions estimates for feedstock conversion
- Consequential analysis for indirect land use and social metrics
- Contribute to ongoing debate over biofuel use in the U.S.

## Acknowledgements

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