5th Annual Forum of the California Biomass Collaborative

Bioenergy Sustainability and Life Cycle Analysis

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Defining Sustainability and Measuring the Environmental Impact of Biofuels

- Energy security and GHG reductions (through EISA) are major drivers of biofuels
- Need to promote the sustainable production of biofuels
- Need quantitative environmental indicators to track over time
- Hundreds of environmental, economic, and agricultural indicators available
- Need baselines against which to measure impacts
- Need to link practices to indicators
International Context

• Many countries are promoting sustainable production of biofuels and best practices, and several have developed sustainability principals, criteria and/or indicators.

• International debate is focusing on verification of sustainable production by mandatory and/or third-party certification based on criteria for sustainability.

• While most countries agree on general principles for protecting agricultural lands and ecosystems and for reducing greenhouse gas emissions, there is little consensus on measures to assess biofuel sustainability.

• While the U.S. is leading on many sustainability issues, it has not compiled a list of best practices or defined a set of sustainability principles, criteria, or indicators.
Principle
E.g., Soil Conservation

Criterion (Standard)
E.g., Preservation of soil health and productivity

Indicator (Metric)
E.g., Annual measurements of select soil properties (soil organic matter, pH, etc.) are within a specified range or consistent with a regional benchmark

Benchmarks and best practices may inform the development of criteria and indicators.

Certification
Mandatory and/or third-party verification that principles have been met. The U.S. supports certification schemes that are voluntary, market-driven, and stakeholder-supported.
Generalized Diagram:
Crop Production

Source: Bill Chism, EPA/OPPTS
Biofuel Crop Production: Inputs and Outputs

**Energy**
- Sun
- Petrochemical (fuel, fertilizer, manufacturing, etc.)

**Physical Factors**
- Climate
- Temperature
- Rainfall
- Soil Characteristics
- Topography
- Slope
- Distance to water

**Crop**
- Energy
- Food
- Compounds

**Atmospheric Carbon**

**Agric Practices**
- Tillage
- Planting
- Crop & Cultivar
- Pest Control

**Water**
- Rainfall (nitrogen)
- Irrigation

**Nutrients**
- Fertilizer
- Soil & Crop Residue

**Crop Production**
- Starch – corn
- Oil Seed – soybean
- Perennial Grass – Switchgrass
- Sugar Crop – Sugarcane
- Woody Biomass - Poplar

**Assets**
- Soil Organic Matter
- Carbon and Minerals
- Water – filter & storage
- Wildlife
- Ecological Services
- Land Use / Consumption

**Air Emissions**
- Nitrogen (NO₂⁻)
- Carbon (tillage)
- Particulates

**Secondary Products (Animal Feed)**
- Distillers Dry Grain
- Glycerol
- Lignin

**Leaching & Runoff**
- Nitrogen (NO₃⁻)
- Phosphorus (H₂PO₄⁻)
- Soil

**Water**
- Recharge (pos)
- Evaporation (neg)

Source: Bill Chism, EPA/OPPTS
Is the Biofuel System Sustainable?

1. Does production of feedstock for biofuel reduce the growth rate of energy consumption and enhance energy security?
2. Do bio-based products and/or co-products enhance economic growth?
3. Does increased production of feedstock for biofuel endanger U.S. and/or global food production?
4. Does production of feedstock for biofuel reduce emissions of greenhouse gas (GHG)?
5. Does increased production of feedstock for biofuel endanger ecosystems and/or biodiversity?
Is the Biofuel System Sustainable? *(Con’t)*

6. Does increased production of feedstock for biofuels result in significant loss of soil, carbon, or other nutrients?

7. Do the technologies and products of the biofuel system protect the environment?

8. Do increased production and use of biofuels result in releases of water pollutants exceeding statutory limits?

9. Do increased production and use of biofuels endanger human health, including through releases of chemical pollutants that exceed statutory limits?
Criteria for Indicators

- The indicator is useful. It answers (or makes an important contribution to answering) a question in the ROE.
- The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.
- The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.
- The underlying data are characterized by sound collection methodologies, data management systems to protect its integrity, and quality assurance procedures.
- Data are available to describe changes or trends and the latest available data are timely.
- The data are comparable across time and space, and representative of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

Source: Denice Shaw, EPA/ORD
## Environmental Impacts of Biofuels: Questions, Criteria, and Indicators – The Beginning

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<tr>
<th>Criteria (Requirements)</th>
<th>Indicators (Metrics)</th>
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| 1. Does production of feedstocks for biofuel reduce the growth rate of energy consumption and enhance energy security? | • Amount of energy used in collection or harvesting of biomass, by MJ/ton  
• Amount of energy used in converting biomass to fuel, per gallon of ethanol  
• Amount of energy used in transport of ethanol, per gallon of ethanol  
• Net displacement of fossil-based energy for transportation fuels |
| The choice of technologies and processes throughout the biofuel supply chain must optimize energy efficiency; the biomass system must reduce the use of petroleum-based products. | |
| 2. Do bio-based products and/or co-products enhance economic growth? | • Economic value of petroleum-based products  
• Direct value added from bio-based fuels  
• Industrial absorption and/or consumer acceptance of bio-based products  
• Quantity (by weight and/or volume) of co-products from biofuel production  
• Value of co-products from biofuel production |
| Biomass products must not have a net negative impact on the economy. | |
Assessing Impacts of the Biofuel System

Baseline data: 2005

Future Trends

Indicators
Exhibit 4-16. Commercial fertilizer use in the U.S., 1960-2005

Based on sales data. Per-acre use based on the acreage of harvested or failed cropland, as determined by USDA’s National Agricultural Statistics Service.

Data source: Lubowski, 2006; Wiebe and Gollehon, 2006
EPA Strategic Framework

- **Feedstock Production**
  - Ag Crops
  - Ag Residues
  - Energy Crops
  - Forest Residues
  - Wastes
  - Harvesting & Collecting
  - Storage
  - Pre-Processing
  - Transportation

- **Feedstock Logistics**

- **Biofuels Production**
  - Fuel types
    - Biochemical Conversion
    - Thermochemical Conversion
    - Anaerobic Digestion

- **Biofuels Distribution**
  - Transportation
  - Storage
  - Dispensing

- **Biofuels End Use**
  - Transportation fuels
    - (in light- & heavy-duty vehicles & trucks, off- road vehicles, locomotives, flight technologies, boats/boats)
  - Power & Generators
  - Chemical Feedstocks for Manufacturing
World Projection of CO$_2$ Emissions, by Sector (IEA, 2006)