Life-Cycle Assessment of the Energy Independence and Security Act of 2007: Ethanol Goals

CORRIM Bio LCI Workshop

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October 20-21, 2008
Overview

Project Introduction
- Energy independence and security act (EISA)
  - Objectives
Life-Cycle Inventory and Assessment
- Modeling infrastructure and methods
- Boundaries
- Product stages
- Data inputs/sources

Next Steps
EISA Renewable Fuel Volume Targets

Source: EISA 2007, Sec. 202, p. 121 Stat 1522-1523
Renewable Fuel Standard (RFS) goals for biofuels penetration are based on specific GHG reductions from the fossil fuel it replaces.

- Biomass-based diesel = 50% reduction
- Advanced biofuels = 50% reduction
- Corn grain-based ethanol = 20% reduction
- Cellulosic Biofuels – 60% reduction
Introduction

Project Objectives
• Farm-to-wheels analysis
• 2005 (base-line) to 2022 (EISA volumes)
• Under the EISA mandates, is 2022 an improvement over 2005 based on:
  – GHG (kg CO2 equivalent)
  – Net energy (MJ)
  – Criteria air pollutants (O3, NOx, CO, SOx, PM, Pb)
  – Water consumption
  – Direct land-use
• Functional units
  – 1 gallon ethanol (fuel cycle results)
  – 1 mile driven (farm-to-wheels results)
Life-Cycle Inventory/Assessment

LCA modeling infrastructure
• SimaPro v.7.1.8 – EarthShift consultants
• EcoInvent 2.0 used for substances and some processes
• All data inputs are parameterized within SimaPro to allow for easy adjustment and transparency.
• Each entry in SimaPro is documented and referenced for transparency.
System boundaries

• Ethanol supply chain for the entire US
• All energy flows associated with production, distribution, and use of ethanol in 2005 and 2022
  – Avoided products (e.g., animal feed, urea), product displacement (e.g., grazing, over winter feed), infrastructure attributed to EISA (construction and maintenance of refineries, fuel distribution infrastructure, fleet differences).
• Indirect land-use change is not included in phase 1.
Life-Cycle Inventory/Assessment

Product stages
- Biomass Production
- Feedstock Transportation and Preprocessing
- Feedstock Conversion
- Ethanol Distribution
- Vehicle end-use
Life-Cycle Inventory/Assessment

Product stages: biomass production

Pre-plant
- Tillage
- Pesticide
- Lime

Planting
- Planting
- Fertilizer

Growing Season
- Fertilizer
- Pesticide
- Water
- Solar energy
- CO₂
- Harvest

Post Harvest
- Multi-use?
- Cover crop?

Feedstocks include: Corn Grain, Corn stover, Switchgrass, Wheat straw (Biochemical), and Forest residues (Thermochemical)
Life-Cycle Inventory/Assessment

Product stages: feedstock transport & preprocessing

Both the 2005 and 2022 corn grain-to-ethanol modules use the current corn-based ethanol industry system for transport, storage, and preprocessing.
Life-Cycle Inventory/Assessment

Product stages: transport & preprocessing

- 2022 transportation and preprocessing is modeled after the “Advanced Uniform-Format Feedstock Supply System”.
  - Separate grain from biomass
  - Remove moisture
  - Preprocess biomass to ensure >4 flowability factor
Life-Cycle Inventory/Assessment

Product stages: conversion

The 2005 and 2022 corn grain-to-ethanol conversion processes were modeled using a dry mill.
Life-Cycle Inventory/Assessment

Product stages: conversion

Feedstock Handling
- Corn Stover
- Recycle

Pretreatment
- Steam & Acid
- CO₂

Saccharification & Fermentation
- Enzyme
- Lignin Residue

Distillation & Ethanol Purification
- Ethanol
- Wastewater Treatment
- Lignin Residue

Dewatering
- Ethanol

Conditioning
- Burner/Boiler Turbogenerator
- Electricity

Solid/Liquid Separation
- Liquor
- Lime
- Gypsum

Lignocellulosic Biomass to Ethanol Process Design and Economics NREL/TP-510-32438
June, 2002 http://www.nrel.gov/docs/fy02osti/32438.pdf
Life-Cycle Inventory/Analysis

Product stages: ethanol distribution

E10, at blending terminal
- Blend ethanol and gasoline
- Gas process includes operation of terminals and refueling station, plus all transportation to refueling station

E85, at blending terminal
- Blend ethanol and gasoline
- Gas process includes operation of terminals and refueling station, plus all transportation to refueling station

E10, pumped into vehicle
- Energy for dispensing E10

E85, pumped into vehicle
- Energy for dispensing E85

2005 base case
Life-Cycle Inventory/Analysis

Product stages: ethanol distribution

- Ethanol from mixed feedstocks, at refueling station
  - Transport of ethanol to refueling station

- E10, at blending terminal
  - Blend ethanol and gasoline
  - Gas process includes operation of terminals and refueling station, plus all transportation to refueling station

- E85, at blending terminal
  - Blend ethanol and gasoline
  - Gas process includes operation of terminals and refueling station, plus all transportation to refueling station

- E10, pumped into vehicle
  - Energy for dispensing E10
  - Blending equipment and infrastructure included

- E85, pumped into vehicle
  - Energy for dispensing E85
  - Blending equipment and infrastructure included

2022 scenario
Life-Cycle Inventory/Assessment

Product stages: vehicle end-use
- Impacts from vehicle manufacture, servicing, fixed costs, and end-of-life impacts are excluded.
- Infrastructure impacts due to additional FFVs
- Operation of FFVs compared to gasoline vehicles.
- Assuming gasoline production remains the same (i.e., no tar sands, CTL, etc.).
Life-Cycle Inventory/Assessment

Data Sources

• Sources vary by model stage
  – Biomass production: survey data (e.g., USDA NASS)
  – Harvest and transport: design report (e.g., INL)
  – Conversion: design reports Biochem & Thermochem (NREL 2002 and 2007, respectively), USDA dry mill Aspen Model
  – Fuel delivery and end use: POLYSYS, GREET 1.8

• Future scenarios utilized projections and best engineering judgment to create a plausible case for 2022.

• Sensitivity Assessment is key for the 2022 scenarios.
Life-Cycle Inventory/Assessment

Next Steps
• Forest residue modules for 2022 thermochemical conversion
• Develop 2022 US fleet/infrastructure projections
• Initial model results
• Stakeholder meetings
• ISO 14040 review process
• Draft report
• Phase 2
Questions…