Chem/ESPM/PH 234 Class 14 Process Emissions

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> How to estimate life-cycle pollutant emissions?

- > Emissions inventories
- > Emissions factors
- > Pollutants of concern
- > Exercise on ethanol versus gasoline emissions
- > Why is spatial variation important?
- > Developing and emissions inventory for your projects

Exercise

Based on Tessum et al. (2012), make a simple process diagram for fuel feedstock production and fuel processing that includes energy used to produce/transport the feedstock. (In the case of gasoline the feedstock is crude oil and in the case of biofuels.

For VOCs and PM 2.5:

- (1) Compare feedstock production of corn ethanol to gasoline
- (2) Compare fuel production of corn ethanol to gasoline
- (3) Compare feedstock production of cellulosic ethanol to gasoline
- (4) Compare fuel production of corn cellulosic to gasoline

Where do negative emissions come from?

What are key assumptions?

Where do the data come from?

If you could look inside GREET to check for uncertainty, name two things you would check



Energy Flows in the U.S. Economy, 2007



Life-Cycle Impacts



Emissions Inventories

http://www.epa.gov/air/aqmportal/management/emissions_inventory/

An emissions inventory is a database that lists, by source, the amount of air pollutants discharged into the atmosphere of a community during a given time period





Emissions Factors

 Emissions factors EF (g/unit activity) relate activity levels to pollutant emissions

Emissions (g/hr) = EF x Activity x CF

CF is a conversion factor

• Examples

- Auto emissions per vehicle mile travels (EF) X miles travel per hour (Activity)
- Butadiene emissions per tonne of oil refined (EF) X tonne/hr refined (Activity)

http://www.epa.gov/ttn/chief/



Technology Transfer Network Clearinghouse for Inventories & Emissions Factors

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Emissions Inventories Emissions Factors Emissions Modeling Clearinghouse

Emission Inventory & Factor Listservs



Emissions Inventories

Emissions Inventories are the basis for numerous efforts including trends analysis, regional, and local scale air quality modeling, regulatory impact assessments, and human exposure modeling.

Emissions Factors

The Emissions Factors & Policy Applications Center (EFPAC) provides information about existing emission factors, the revision of existing factors and the development of new factors from stationary point and non point sources.

Emissions Modeling

The Emissions Modeling Clearinghouse (EMCH) has been designed to support and promote emission modeling activities both internal and external to the EPA. Through this site the EPA intends to distribute emissions model input formatted inventories based on the latest versions of its National Emission Inventory databases.

Emissions Monitoring Knowledge Base

EPA's Monitoring Knowledge Base Site provides information about monitoring techniques for air pollution control. The monitoring information is presented by industry type and by control technique.

CHIEF

U.S. Environmental Protection Agency

Life Cycle Inventories

A life cycle inventory (LCI) includes information on all of the environmental inputs and outputs associated with a product or service

material and energy requirements as well as emissions and wastes

- Seems simple but can be a challenging
 - Geographical variations
 - > Data quality
 - > Choice of technology

> Resources

Ecolnvent Database (http://www.ecoinvent.ch)

Pollutants of Concern

Greenhouse gases

- Criteria air pollutants
 - Particulate matter (PM10; Primary and secondary PM2.5
 - NOx and SOx
 - Ozone
 - Carbon monoxide and lead

> Additional pollutants of concern

- Hazardous air pollutants (benzene, butadiene, acetaldehyde, formaldehyde)
- Other toxic multimedia pollutants (toluene)
- Novel chemicals used as fuels and fuel processing
 - Bio-butanol
 - Dimethylfuran (DMF)

Environmental Science & lechnology



ethanol exhibit different temporal patterns than from gasoline, reflecting seasonal aspects of farming activities. Enhanced chemical speciation beyond current GREET model capabilities is also described. Life cycle fine particulate matter emissions are higher for ethanol from corn grain than for ethanol from corn stover; for black carbon, the reverse holds. Overall, our results add to existing state-of-the-science transportation fuel LCI by providing spatial and temporal disaggregation and enhanced chemical speciation, thereby offering greater understanding of the impacts of transportation fuels on human health and opening the door to advanced air dispersion modeling of fuel life cycles.

A Spatially and Temporally Explicit Life Cycle Inventory of Air Pollutants from Gasoline and Ethanol in the United States

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Supporting Information

ABSTRACT: The environmental health impacts of transportation depend in part on where and when emissions occur during fuel production and combustion. Here we describe spatially and temporally explicit life cycle inventories (LCI) of air pollutants from gasoline, ethanol derived from corn grain, and ethanol from corn stover. Previous modeling for the U.S. by Argonne National Laboratory (GREET: Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) suggested that life cycle emissions are generally higher for ethanol from corn grain or corn stover than for gasoline. Our results show that for ethanol, emissions are concentrated in the Midwestern "Corn Belt". We find that life cycle emissions from pubs.acs.org/est



Biomass Production

Water use in biomass production

- Developed metrics for water consumption
- Projected water use by crop type

Land use in biomass production

- Competition with food crops
- Climate needs for biomass crops
- > Avoiding pesticides and added nutrients





Courtesy of C. Somerville, UC Berkeley

Climate Impacts of biomass production

Energy requirements

- Planting and crop management
- Harvesting
- Storage and transport

Biofuel Production



Exercise

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> Argonne National Laboratory

> About 15 years in development

MS Excel spreadsheet

For more than 100 fuel production pathways it estimates across the life cycle:

- ➤ GHG emissions
- Criteria pollutants (urban and total)
- ➤ Energy use

Fuel Types in the GREET Model



Location (and Time) of Emissions Matter



county-level resolution for emissions impacts



Cumulative population PM2.5 intake in mg/d from PM2.5 emissions in kg/d for each US County (expressed as intake fraction mg/kg)