GHGENIUS
LCA Model for Transportation Fuels

Don O'Connor

$(S\&T)^2$ Consultants Inc.

www.ghgenius.ca

Agenda

- GHGenius Introduction
- Biofuels Results
- Key Inputs
- Analysis Gaps

Model Background

- Based on a Lotus 123 spreadsheet model developed by Dr. Mark Delucchi, University of California, Davis in the late 1980’s for estimating transportation emissions
- In 1998 Delucchi added some specific Canada information for a US DOE, NRCan project
- In 1999, Levelton Engineering was asked by NRCan to use the model for the Transportation Table of the National Climate Change Process

Model Background

- Since 1999 the model, now called GHGENIUS, has been used for studies for Agriculture and Agri-Food Canada, Natural Resources Canada, a number of the Provinces, some industries, and a number of individual companies
- Many new pathways have been added so that there are now over 200 transportation fuel pathways in the model. Much more Canadian specific data in the model
- The model was transitioned to Excel and SI units and is now available with an updated guide
- Documentation includes an over 500 page GHGENIUS guide and numerous reports. Some Delucchi documentation is still relevant

Why GHGENIUS?

- Fully transparent, relatively user friendly
- Transportation specific but covers most energy sources and many materials manufacturing processes and land use changes
- Best Canadian database available, some regionalization
- Good American database
  - Allows comparison of Canadian and US applications of the same process
  - There are some significant differences in the industrial infrastructure between the countries
- Has some economic tools incorporated

Model Scope

- Covers raw materials production to end use.
- Lifecycle Stages
  - Raw Materials Acquisition
    - Feedstock production and recovery
    - Feedstock transmission
    - Fertilizer manufacture
    - Land use changes
    - Leaks and flaring associated with fossil fuels
  - Manufacturing
    - Fuel production
    - Fuel storage and distribution
    - Fuel dispensing
    - Emissions displaced by co-products
  - Vehicle operation
  - Vehicle materials, assembly and transport.

Inventory Data

- A variety of data sources used for inventory data
  - For existing processes,
    - Statistics Canada
    - Industry reports
    - GHG Registries (formerly VCR)
  - For new to Canada processes
    - Foreign operating data
    - Engineering studies
    - Basic scientific assessment

Inventory Data

- Where possible relies on public data. US data relies heavily on US Census and DOE EIA data
- Generally uses industry averages rather than plant specific data
- The model is dynamic in that changes in one fuel cycle can effect many other cycles. Iterates to solve circular references
- Unlike some other models it allows the inputs to be in common units and the model calculates the energy impacts

Model Impact Assessment

- Capable of estimating life cycle emissions of the primary greenhouse gases, the criteria air contaminants (CAC), and the energy balance
- Greenhouse Gases (GHG)
  - Uses IPCC weighting factors as default values
  - Carbon dioxide
  - Methane
  - Nitrous Oxide
  - Chlorofluorocarbons and Hydrofluorocarbons

Model Impact Assessment

- Criteria Air Contaminants
  - Carbon monoxide,
  - Nitrogen oxides,
  - Non-methane organic compounds,
  - Sulphur dioxide,
  - Total Particulate Matter.
- Energy required per unit of energy produced
- Calculates cost effectiveness (\$/tonne CO_2 eq displaced) versus gasoline and diesel engines

Interpretation Capabilities

- GHGENIUS can calculate emissions for any year between 1996 and 2050
  - Correlations for changes in energy and process parameters with time are stored in the model. Based on historical trends or in some cases forecasts, e.g. NEB for power and oil production
- Results are calculated for each stage of the lifecycle and for each contaminant
- Capable of estimating emissions in Canada, the United States, Mexico as well as regionally, east, central, or west in North America, and India
- Some pathways can be analyzed provincially

Fuel Pathways

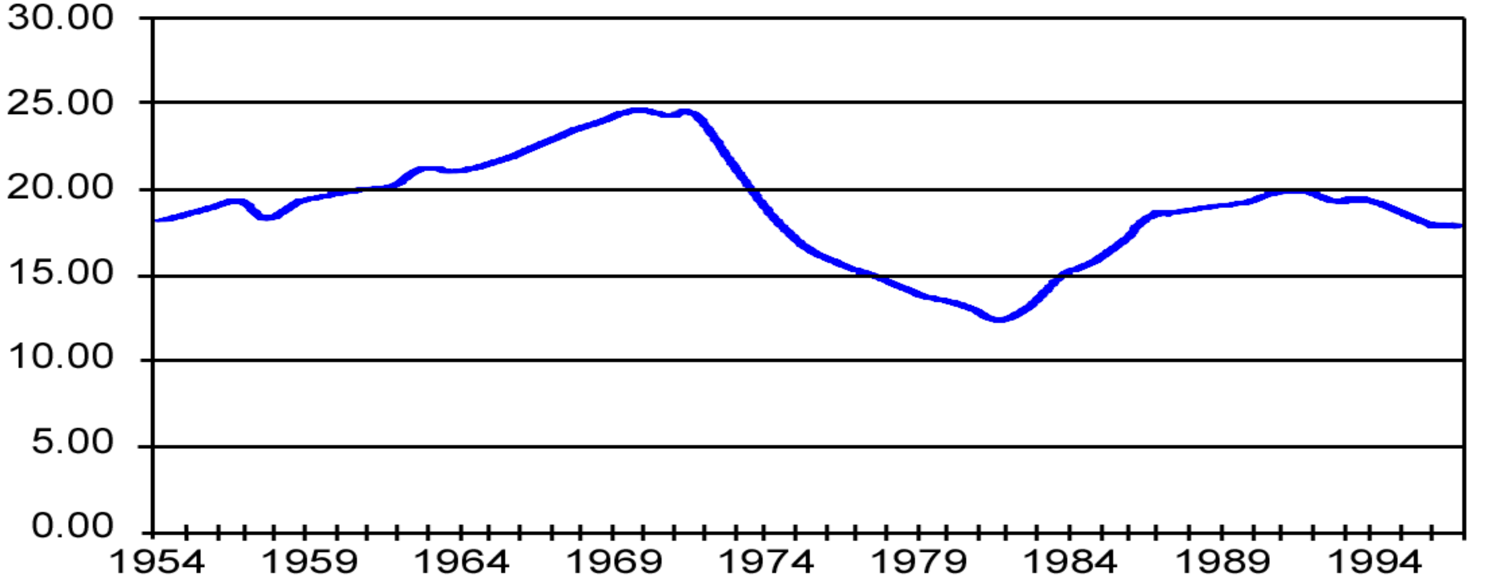
	Coal	Gasoline	Gasoline Lo S	Diesel	Fuel Oil	Still Gas	LPG	Coke	FT Distillate	HRD	NG	Hydrogen	Methanol	Ethanol	Butanol	Biodiesel	DME	Mixed Alcohol	Electricity
Coal	X								X		X	X	X						X
Crude Oil		X	X	X	X	X	X	X				X							X
Natural Gas							X		X		X	X	X				X	X	X
Uranium												X							X
Electricity												X							
Wood									X		X	X	X	X				X	X
Corn Stover											X	X	X	X					
Wheat Straw														X					
Switchgrass														X					
Hay														X					
Manure											X								
Corn												X		X	X				
Wheat												X		X					
Barley														X					
Peas														X					
Sugarcane														X					
Sugar beets														X					
Canola										X						X			
Soybeans										X						X			
Palm										X						X			
Tallow										X						X			
Yellow Grease										X						X			
Fish Oil										X						X			
Algae										X						X			
Jatropha										X						X			
RDF									X									X	
LFG												X	X						
Used Oil					X														

Biofuel Results

- All fuel systems are always in transition.
  - Technological improvement vs. Mother Nature
  - Some are becoming more carbon intense and some less
- Carbon intensity will vary significantly depending on where the feedstock is produced and converted to biofuels
- Model results are dependent on the quality of the data

Technology vs. Mother Nature

- US Crude Oil Production
  - Net Energy Ratio (energy produced per unit of energy consumed)



What Drives Biofuel Results?

- Since LCAs are done on a relative basis, the emissions for the gasoline and diesel systems are also important
  - Biggest gaps for these systems are land use emissions from seismic activity, clearing for drill pads, access roads, and pipeline right of ways, and energy and emission data that is truly representative of crude oil production on a world wide basis

What Drives Biofuel Results?

- Direct farm energy use
  - Most analyses utilize USDA survey results, but reported energy use is much higher than derived from bottom up calculations
  - These surveys were only done every five years and are no longer being done. Significant variation from survey to survey
  - FASOM “data” was even much higher than USDA survey information
  - Uncertainty about the system boundaries

What Drives Biofuel Results?

- Soil emissions
  - GHGenius uses N_2O emission factors aggregated at the provincial level. Range from high to low is 3 to 1
  - Similar regional information for the United States has been developed but it is not publicly available in a form that is useful for LCA work
  - At the national level both Canada and the US claim that soil carbon is increasing in agricultural soils but good regional data is not available in the form required

What Drives Biofuel Results?

- Plant process energy
  - Almost all soybean biodiesel LCA work done in the world uses the soybean crushing energy from the NREL 1998 report. That report used data from a single plant from about 1980. It is double what the industry is using today
  - Industry Associations need to undertake comprehensive, regular energy use and productivity surveys of their members to build credible time series of information on performance

What Drives Biofuel Results?

- Allocation Approach
  - Allocation is an issue in almost all systems, petroleum systems included
  - System expansion is preferred but there are even issues with this approach
  - There should be some consistency between the systems being compared or at least an understanding of the uncertainty imposed by inconsistency

Closing Thoughts

- Biofuel systems are not that unique. There are significant data gaps in almost all of the potential transportation fuel systems
- Almost all of the data that we have was originally collected for some purpose other than undertaking an LCA
  - In many cases it is difficult to confirm system boundaries and in some cases even units of the data
- An LCA generally won't tell you what works best, is the lowest cost, or has the optimum social impact, etc., so it must be used as part of a process to reach decisions. LCAs were never intended to be the sole decision criteria

Questions?

Thank You