Publications of the GREET Model Development and Applications
Center for Transportation Research
Argonne National Laboratory
(February 2010)

Title:
GREET 1.0 – Transportation Fuel Cycles Model: Methodology and Use

Authors:
Wang, M.

Publication Date:
June 1996

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. ANL/ESD-33. Available at http://www.transportation.anl.gov/pdfs/TA/500.pdf.

Content:
This is the first report to document the development of the first GREET version with general simulation approaches of fuel-cycle analysis.

Title:
Fuel-Cycle Fossil Energy Use and Greenhouse Gas Emissions of Fuel Ethanol Produced from U.S. Midwest Corn

Authors:
Wang, M.; Saricks, C.; Wu, M.

Publication Date:
December 1997

Venue of Availability:
Research report prepared for the Illinois Department of Commerce and Community Affairs by the Center for Transportation Research, Argonne National Laboratory. Available at http://www.transportation.anl.gov/pdfs/TA/141.pdf.

Content:
This is the first report to document key assumptions and results of corn-based ethanol simulated with the GREET model. The report documents different methods of dealing with co-products from corn ethanol plants. It is the first report to document detailed data and analysis of N_2O emissions from cornfields. It is the first report to present Argonne's results on energy and GHG emissions by corn ethanol relative to petroleum gasoline.

Title:
Effects of Fuel Ethanol Use on Fuel-Cycle Energy and Greenhouse Gas Emissions

Authors:
Wang, M.; Saricks, C.; Santini, D.

Publication Date:
January 1999

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. ANL/ESD-38. Available at http://www.transportation.anl.gov/pdfs/TA/58.pdf.

Content:
This report presents updated results of energy use and GHG emissions of corn ethanol simulated with the GREET model. The report documents displacement ratios between co-products of corn ethanol and conventional animal feeds and inclusion of GHG effects of direct land use changes.

Title:
GREET 1.5 – Transportation Fuel-Cycle Model, Volume 1: Methodology, Development, Use, and Results

Authors:
Wang, M.

Publication Date:
August 1999

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. ANL/ESD-39, Vol.1. Available at
http://www.transportation.anl.gov/modeling_simulation/GREET/pdfs/esd_39v1.pdf.

Content:
This report thoroughly documents methodologies, key assumptions and their data sources, and results of fuel-cycle analysis for vehicle/fuel systems with the GREET model. It lays out calculations logistics for energy use and emissions of well-to-pump stages. It also presents results of several major fuel-cycle analysis studies available at that time. It is also the first report to present WTW results of all vehicle/fuel systems in the GREET model.

Title:
A Full Fuel-Cycle Analysis of Energy and Emissions Impacts of Transportation Fuels Produced from Natural Gas

Authors:
Wang, M.; Huang, H.

Publication Date:
December 1999

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. ANL/ESD-40. Available at http://www.transportation.anl.gov/pdfs/TA/13.pdf.

Content:
This report documents the development of transportation fuel pathways based on natural gas and the results of these pathways. It presents fuel production technologies, key assumptions and their data sources, and results of natural gas-based fuel production pathways. This report reflects revisions of key assumptions regarding NG-based fuels in the GREET version at that time.

Title:
Contribution of Feedstock and Fuel Transportation to Total Fuel-Cycle Energy Use and Emissions

Authors:
He, D.; Wang, M.

Publication Date:
2000

Venue of Availability:
Society of Automotive Engineers (SAE) paper 2000-01-2976. Abstract available at http://www.transportation.anl.gov/pdfs/TA/266.pdf.

Content:
This paper documents data sources and configuration of the GREET model for simulating transportation activities inside of GREET. Transportation of feedstocks and fuels via different transportation modes requires use of various fuels and generates air pollutant emissions. Storage of liquid and gaseous fuels is subject to fuel losses, which also lead to air pollutant emissions. In fuel-cycle analyses, while feedstock recovery and fuel production have been studied carefully, transportation and storage of feedstocks and fuels are often not studied in detail. As part of a comprehensive fuel-cycle analysis at Argonne National Laboratory, we characterize transportation modes for different feedstock types, fuel types, production locations, and consumption locations. We collected data on the energy intensities of various transportation modes and the distances traveled for given feedstocks and fuels. We included five transportation modes—ocean tanker, barge, truck, rail, and pipeline—for various feedstocks and fuels. On the basis of the collected data, we estimated energy use and emissions associated with transportation and storage of gasoline, diesel, compressed natural gas, liquefied natural gas, liquefied petroleum gas, methanol, ethanol, gaseous and liquid hydrogen, and Fischer-Tropsch diesel. Our assessment indicates that, in some cases, transportation, storage, and distribution (T&S&D) can make a significant contribution to total fuel-cycle energy use and emissions for transportation fuels.

Title:
Fuel-Cycle Emissions for Conventional and Alternative Fuel Vehicles: An Assessment of Air Toxics

Authors:
Winebrake, J.; He, D.; Wang, M.

Publication Date:
August 2000

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. ANL/ESD-44. Available at http://www.transportation.anl.gov/pdfs/TA/137.pdf.

Content:
This report provides information on Argonne's efforts to use the GREET model to estimate air toxics emissions. GREET was modified to account for the following important toxic pollutants: acetaldehyde, benzene, 1,3-butadiene, and formaldehyde. This is the first to consider fuel-cycle emissions of these pollutants for alternative transportation fuels and advanced vehicle technologies. Through this study, an air toxics version of the GREET model was developed.

Title:
Development and Use of GREET 1.6 Fuel-Cycle Model for Transportation Fuels and Vehicle Technologies

Authors:
Wang, M.

Publication Date:
June 2001

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. ANL/ESD/TM-163. Available at http://www.transportation.anl.gov/pdfs/TA/153.pdf.

Content:
This report documents new pathways, including petroleum to crude naphtha, NG to naphtha via the Fischer-Tropsch process, and electricity to gaseous hydrogen and liquid hydrogen via electrolysis, and key results of GREET 1.6. This was the first GREET version to have a graphic user interface that interacted with the spreadsheet and to incorporate uncertainty analysis of the

fuel pathways. Also, in previous GREET versions, energy use and emissions from transporting energy feedstocks and fuels were simulated by using energy efficiencies as inputs to different transportation activities — similar to simulations of feedstock and fuel production activities. In the new version, transportation-related activities are simulated by using input parameters, such as transportation modes, transportation distances, energy use intensities for various transportation modes, and other factors.

Title:
Well-to-Wheel Energy Use and Greenhouse Gas Emissions of Advanced Fuel/Vehicle Systems: A North American Analysis, Volume 3, Well-to-Tank Energy Use and Greenhouse Gas Emissions of Transportation Fuels

Authors:
General Motors Corporation, Argonne National Laboratory, BP, ExxonMobil, Shell

Publication Date:
June 2001

Venue of Availability:
Research report, by General Motors Corporation, Argonne National Laboratory, BP, ExxonMobil, and Shell. ANL/ES/RP-104528. Available at http://www.transportation.anl.gov/pdfs/TA/165.pdf.

Content:
This report documents work conducted by several organizations (including Argonne) where GREET was used to examine energy and GHG emission effects of over 100 vehicle/fuel systems. Through this effort, the stochastic simulations feature was developed for the GREET model. In addition, petroleum refining efficiencies were revised in GREET based on data from three petroleum refining studies. WTP energy efficiencies in GREET were revised through this effort.

Title:
The Energy Balance of Corn Ethanol: An Update

Authors:
Shapouri, H.; Duffield, J.A.; Wang, M.

Publication Date:
July 2002

Venue of Availability:
Research report by the U.S. Department of Agriculture, Office of the Chief Economist. Agricultural Economic Report No. 814. Available at http://www.transportation.anl.gov/pdfs/AF/265.pdf.

Content:
This report documents updated data on corn farming energy use and energy use in corn ethanol plants. The farming and ethanol production energy use from this report were used to update GREET corn ethanol simulation pathways.

Title:
Soil Carbon Changes for Bioenergy Crops

Authors:
Andress, D.

Publication Date:
September 2002

Venue of Availability:
Research report prepared by David Andress & Associates, Inc. for Argonne National Laboratory. Available at http://www.transportation.anl.gov/pdfs/AF/499.pdf.

Content:
This report details the characterization of the soil carbon sequestration for three bioenergy crops (switchgrass, poplars, and willows) for use in the GREET model. In addition, this report documents methodologies, key issues, and data needs in addressing soil carbon from land use changes caused by biofuel production in the context of a life-cycle analysis. Bioenergy crops, which displace fossil fuels when used to produce ethanol, bio-based products, and/or electricity, have the potential to further reduce atmospheric carbon levels by building up soil carbon levels, especially when planted on lands where these levels have been reduced by intensive tillage. A three-step process is used to conduct this study. First, the results of an economic analysis were used to determine crop yields, geographic locations for bioenergy crop production and land use changes. Next, a soil carbon model was used to estimate regional soil carbon changes on a per hectare basis over time, based on the regional yield and land use data calculated from the economic analysis. Finally, the data from the first two steps were combined to calculate the soil changes per unit of biomass as a function of time. In addition, the regional data was aggregated to make a national estimate. These results were applied to the methodology used in GREET to

assign carbon changes to a unit of biomass (grams of carbon dioxide per dry ton of biomass) by calculating the total soil carbon changes over the life of the bioenergy crop farm and divide the resulting value by the total biomass production during that period.

Title:
Fuel Choices for Fuel-Cell Vehicles: Well-to-Wheels Energy and Emission Impacts

Authors:
Wang, M.

Publication Date:
October 2002

Venue of Availability:
Journal of Power Sources, 112: 307–312. Abstract available at
http://www.transportation.anl.gov/pdfs/TA/268.pdf.

Content:
This is the first paper to document key assumptions of hydrogen production pathways and results from the GREET model. It presents the data sources for some of the key assumptions.

Title:
Assessment of Well-to-Wheels Energy Use and Greenhouse Gas Emissions of Fischer-Tropsch Diesel

Authors:
Wang, M.

Publication Date:
October 2002

Venue of Availability:
Research report for the U.S. Department of Energy by the Center for Transportation Research, Argonne National Laboratory. Available at
http://www1.eere.energy.gov/vehiclesandfuels/epact/pdfs/ftd_docket/greenhouse_gas.pdf.

Content:
This report documents updated analysis of Fischer-Tropsch diesel produced from natural gas. It was prepared from a ruling by the U.S. Department of Energy for alternative fuel definitions

under the 1992 Energy Policy Act. Data on FT diesel production from several EPACT petitions were used in this analysis. As a result, simulations of FT diesel production from natural gas in GREET were updated.

Title:
Fuel-Cycle Energy and Emission Impacts of Ethanol-Diesel Blends in Urban Buses and Farming Tractors

Authors:
Wang, M.; Saricks, C.; Lee, H.

Publication Date:
July 2003

Venue of Availability:
Research report prepared for the Illinois Department of Commerce and Economic Opportunities by the Center for Transportation Research, Argonne National Laboratory. Available at http://www.transportation.anl.gov/pdfs/TA/280.pdf.

Content:
This report documents WTW analysis of diesel and ethanol blends for use in urban buses and farming tractors. Through this study, energy use in fertilizer plants is thoroughly examined. Also, N_2O emissions from cornfields are updated. Both are reflected in the GREET version developed at that time.

Title:
Allocation of Energy Use and Emissions to Petroleum Refining Products: Implications for Life-Cycle Assessment of Petroleum Transportation Fuels

Authors:
Wang, M.; Lee, H.; Molburg, J.

Publication Date:
2004

Venue of Availability:
International Journal of Life-Cycle Assessment, 9 (1): 34-44. Available at http://www.transportation.anl.gov/modeling_simulation/GREET/pdfs/IJLCA-2004.pdf.

Content:

This paper lays the groundwork for allocation methods of dealing with multiple products in petroleum refineries for GREET simulations. Studies to evaluate the energy and emission impacts of vehicle/fuel systems have to address allocation of the energy use and emissions associated with petroleum refineries to various petroleum products because refineries produce multiple products. The allocation is needed to evaluate the energy and emission effects of individual transportation fuels. In this study, we seek a means of allocating total refinery energy use among various refinery products at the level of individual refinery processes. We present a petroleum refinery-process-based approach to allocating energy use in a petroleum refinery to petroleum refinery products according to mass, energy content, and market value share of final and intermediate petroleum products as they flow through the refining processes. By using published energy and mass balance data for a simplified U.S. refinery, we developed a methodology and used it to allocate total energy use within a refinery to various petroleum products. The approach accounts for energy use during individual refining processes by tracking product stream mass and energy use within a refinery. The energy use associated with an individual refining process is then distributed to product streams by using the mass, energy content, or market value share of each product stream as weighting factors.

The results from this study reveal that product-specific energy use based on the refinery process-level allocation differs considerably from that based on the refinery-level allocation. We calculated well-to-pump total energy use and greenhouse gas (GHG) emissions for gasoline, diesel, LPG, and naphtha. For gasoline, the efficiency estimated from the refinery-level allocation underestimates gasoline energy use relative to the process-level-based gasoline efficiency. For diesel fuel, the well-to-pump energy use for the process-level allocations with the mass- and energy-content-based weighting factors is smaller than that predicted with the refinery-level allocations. However, the process-level allocation with the market-value-based weighting factors has results very close to those obtained by using the refinery-level allocations. For LPG, the refinery-level allocation significantly overestimates LPG energy use. For naphtha, the refinery-level allocation overestimates naphtha energy use. The GHG emission patterns for each of the fuels are similar to those of energy use.

Title:

Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems — A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions

Authors:

Brinkman, N.; Wang, M.; Weber, T; Darlington, T.

Publication Date:

May 2005

Venue of Availability:
Research report by General Motors Corporation and Argonne National Laboratory. Available at http://www.transportation.anl.gov/pdfs/TA/339.pdf.

Content:
This report documents the update of criteria pollutant emission factors for stationary combustion sources and motor vehicles powered with different transportation fuels. Using data from several EPA emission databases, distribution functions for key emission factors of criteria pollutants were developed for GREET. The report presents WTW results of criteria pollutants as well as energy use and GHG emissions of more than 100 vehicle systems.

Title:
Mobility Chains Analysis of Technologies for Passenger Cars and Light-Duty Vehicles Fueled with Biofuels: Application of the GREET Model to the Role of Biomass in America's Energy Future (RBAEF) Project

Authors:
Wu, M.; Wu, Y.; Wang, M.

Publication Date:
May 2005

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. Available at http://www.transportation.anl.gov/pdfs/TA/344.pdf.

Content:
This report documents the production of multiple cellulosic biofuels from switchgrass via biochemical and thermochemical conversions. Bioethanol was produced through consolidated bioprocessing. Bio-Fischer-Tropsch diesel, bio-Fischer-Tropsch naphtha, bio-dimethyl-ether, and co-product bio-electricity were produced through thermochemical gasification followed by syngas synthesis and GTCC or steam turbine. Pathways analysis was based on process simulation by Dartmouth College and Princeton University. They evaluated energy and GHG benefits of cellulosic biofuels in the year 2025. Results of this study show various production options using switchgrass-based biofuel, their fossil energy use, and life cycle GHG emission reductions relative to conventional gasoline. GREET's herbaceous ethanol pathway was updated through this effort.

Title:
Updated Energy and Greenhouse Gas Emission Results of Fuel Ethanol

Authors:
Wang, M.

Publication Date:
September 2005

Venue of Availability:
15th International Symposium on Alcohol Fuels*,* Sept. 26-28, 2005, San Diego, CA. Available at http://www.transportation.anl.gov/pdfs/TA/375.pdf.

Content:
This paper summarizes key issues affecting WTW energy and emission results of corn and cellulosic ethanol. It is the first paper to discuss historical trends of key factors such as corn farming and ethanol production. It is also the first paper to present the energy balance of corn ethanol.

Title:
Might Canadian Oil Sands Promote Hydrogen Production for Transportation? Greenhouse Gas Emission Implications of Oil Sands Recovery and Upgrading

Authors:
Larsen, R.; Wang, M.; Wu, Y.; Vyas, A.; Santini, D.; Mintz, M.

Publication Date:
2005

Venue of Availability:
World Resource Review 17: 220-242. Abstract available at http://www.transportation.anl.gov/pdfs/TA/363.pdf.

Content:
This paper documents key assumptions of oil sands simulations in GREET. In this paper, we analyze energy use and GHG emissions of Canadian oil sands recovery and upgrading and compare the results with those of current practices (e.g., where steam and hydrogen are produced with natural gas) and alternative practices of providing steam and hydrogen. Although we found that current practices require a large amount of natural gas and generate significant amounts of

GHGs, alternatives such as using nuclear power to provide steam and hydrogen can help reduce natural gas requirements and reduce GHG emissions. In contrast, if coal is used to generate steam and hydrogen, GHG emissions could increase to levels that exceed those associated with current practices. We realize that nuclear-based options are long-term options. However, there is also an anticipated long-term demand for hydrogen for stationary and transportation applications. Although vehicles using hydrogen as a fuel are still under research and development, the immediate demand for hydrogen by oil sands operations could help jumpstart high-volume, low-carbon hydrogen production technologies, such as nuclear-based options. Low-emissions hydrogen production operations for oil sands operations could thereby offer a test bed for low-emission hydrogen production options for the transition to a hydrogen economy.

Title:
User Manual for Stochastic Simulation Capability in GREET

Authors:
Subramanyan, K.; Diwekar U. M.

Publication Date:
December 2005

Venue of Availability:
Research Report for Argonne National Laboratory by Vishwamitra Research Institute. Available at http://www.transportation.anl.gov/pdfs/TA/357.pdf.

Content:
This report documents the development of the stochastic simulation features in GREET 1.7. It also presents steps in the stochastic simulation features in GREET.

Title:
Well-to-Wheels Analysis of Energy Use and Greenhouse Gas Emissions of Hydrogen Produced with Nuclear Energy

Authors:
Wu, Y.; Wang, M.; Vyas, A. D.; Wade, D. C.; Taiwo, T. A.

Publication Date:
August 2006

Venue of Availability:
Nuclear Technologies 155: 92–207. Abstract available at
http://www.transportation.anl.gov/pdfs/TA/380.pdf.

Content:
This paper documents key assumptions of nuclear hydrogen pathways and GREET expansion to include them. In this study, the GREET model was expanded to include four nuclear H_2 production pathways: (1) H_2 production at refueling stations via electrolysis using light water reactor-generated electricity; (2) H_2 production in central plants via thermo-chemical water cracking using heat from high temperature gas-cooled reactor (HTGR); (3) H_2 production in central plants via high-temperature electrolysis using HTGR-generated electricity and steam; and (4) H_2 production at refueling stations via electrolysis using HTGR-generated electricity. The WTW analysis of these four options include these stages: uranium ore mining and milling; uranium yellowcake transportation; uranium conversion; uranium enrichment; uranium fuel fabrication; uranium fuel transportation; electricity or H_2 production in nuclear power plants; H_2 transportation; H_2 compression; and H_2 FCVs operation.

Title:
Fuel-Cycle Assessment of Selected Bioethanol Production Pathways in the United States

Authors:
Wu, M.; Wang, M.; Huo, H.

Publication Date:
December 2006

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. ANL/ESD/06-07. Available at http://www.transportation.anl.gov/pdfs/TA/377.pdf.

Content:
This report documents development of pathways of producing ethanol from corn stover and forest residues in GREET. Corn stover-based ethanol is produced via biochemical conversion process based on NREL's bioconversion process simulation. Forest wood residue is a feedstock to produce multiple alcohols, ethanol, methanol, butanol, pantenol, etc., via a mixed alcohol process developed by NREL. This work is part of a DOE OBP funded 30x30 study. We re-examined fertilizer use (nitrogen, phosphorus, and potassium) and irrigation needs in the thirteen major corn-growing states, based on current USDA data. Net nitrogen requirement and N_2O emissions as a result of corn stover harvest for cellulosic ethanol production was analyzed. As part of this effort, we conducted a life cycle assessment of energy use in farming machinery for

the equipment used to farm corn. The assessment accounts for steel and rubber production, refining, parts production and assembly of the equipment. A historical comparison of farming machinery-embodied energy was presented. Through this effort, GREET was expanded to include the corn stover to ethanol pathway and the forest wood residue to ethanol pathway. In addition, a farming machinery embodied energy database was included in the ethanol pathway in GREET.

Title:
Development and Applications of GREET 2.7 — The Transportation Vehicle-Cycle Model

Authors:
Burnham, A.; Wang, M.; Wu, Y.

Publication Date:
November 2006

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. ANL/ESD/06-5. Available at http://www.transportation.anl.gov/pdfs/TA/378.pdf.

Content:
This report details the development and application of the GREET 2.7 model. The vehicle-cycle module in GREET evaluates the energy and emission effects associated with vehicle material recovery and production, vehicle component fabrication, vehicle assembly, and vehicle disposal/recycling. With the addition of the vehicle-cycle module, the GREET model now provides a comprehensive, lifecycle-based approach to compare the energy use and emissions of conventional and advanced vehicle technologies (e.g., hybrid electric vehicles and fuel cell vehicles). The current model includes six vehicle combinations consisting of a conventional material or lightweight material version of a mid-size passenger car with either an internal combustion engine, an internal combustion engine with hybrid configuration, or a fuel cell with hybrid configuration. The model calculates the energy use and emissions that are required for vehicle component production; battery production; fluid production and use; and vehicle assembly, disposal, and recycling. This report also presents vehicle-cycle modeling results. In order to put these results in a broad perspective, the fuel-cycle model (GREET 1.7) was used in conjunction with the vehicle-cycle model (GREET 2.7) to estimate total energy-cycle results.

Title:
Operating Manual for GREET: Version 1.7

Authors:
Wang, M.; Wu, Y.; Elgowainy, A.

Publication Date:
February 2007

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. ANL/ESD/05-3. Available at http://www.transportation.anl.gov/pdfs/TA/353.pdf.

Content:
This is the operating manual of GREET 1.7. It lists the more than 100 fuel production pathways and 70 vehicle/fuel systems that are simulated and describes the content each of the 27 individual working sheets in this version. It also explains to users the new GREET simulation features and simulations steps.

Title:
Life-Cycle Energy and Greenhouse Gas Emission Impacts of Different Corn Ethanol Plant Types

Authors:
Wang, M.; Wu, M.; Huo, H.

Publication Date:
April 2007

Venue of Availability:
Environmental Research Letters, Vol. 2 (2007), 024001. Abstract available at http://www.transportation.anl.gov/pdfs/AF/497.pdf.

Content:
This paper documents key assumptions of corn ethanol plant energy use by process fuel types. We examine nine corn ethanol plant types categorized according to the type of process fuels employed, use of combined heat and power, and production of wet distillers grains and solubles. Process fuels in corn ethanol plants include natural gas, coal, wet DGS, and wood chips. We found that these ethanol plant types can have distinctly different energy and greenhouse gas emission effects on a full fuel-cycle basis. In particular, greenhouse gas emission impacts can

vary significantly—from a 3% increase if coal is the process fuel, to a 52% reduction if wood chips are used. As a result, the GREET model was expanded to include these process fuels for corn ethanol plants.

Title:
Life-Cycle Assessment of Corn-Based Butanol as a Potential Transportation Fuel

Authors:
Wu, M.; Wang, M; Liu, J.; Huo, H.

Publication Date:
November 2007

Venue of Availability:
Research report. Center for Transportation Research, Argonne National Laboratory. ANL/ESD/07-10. Available at http://www.transportation.anl.gov/pdfs/AF/448.pdf.

Content:
This report documents the development and simulation of corn-based butanol through advanced ABE (acetone, butanol, and ethanol) fermentation. The production pathway produces bio-butanol as a fuel blend, large quantity of co-product bio-acetone, and small amount of bio-ethanol. First, a process simulation for corn-based butanol production was conducted using ASPEN Plus. The simulation was partly based on USDA's corn ethanol dry-mill process model for the process steps prior to fermentation. The upstream production process steps were integrated into ABE fermentation and downstream processing for products separation, which was simulated using the most recent literature values. Results from the ASPEN model served as inputs to estimate life cycle energy use and associated emissions. The report also presents a WTW bio-butanol used in LDV and a cradle-to-gate analysis of bio-acetone. Results from this effort were incorporated into GREET for the corn butanol pathway and corn ethanol pathway.

Title:
Estimation of Energy Efficiencies of U.S. Petroleum Refineries

Authors:
Wang, M.

Publication Date:
March 2008

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. Available at http://www.transportation.anl.gov/modeling_simulation/GREET/pdfs/energy_eff_petroleum_refineries-03-08.pdf.

Content:
This report documents updated petroleum refinery energy efficiencies and data sources. The new efficiencies are used in GREET 1.8.

Title:
Life-Cycle Assessment of Energy and Greenhouse Gas Effects of Soybean-Derived Biodiesel and Renewable Fuels

Authors:
Huo, H.; Wang, M.; Bloyd, C.; Putsche, V.

Publication Date:
March 2008

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. ANL/ESD/08-2. Available at http://www.transportation.anl.gov/pdfs/AF/467.pdf.

Content:
This report documents development of soybean-based renewable diesel and renewable gasoline pathways and update of soybean-based biodiesel pathways in GREET 1.8. We assessed the life-cycle energy and greenhouse gas (GHG) emission impacts of three soybean-derived fuels by expanding, updating, and using the GREET model including biodiesel produced from soy oil transesterification; renewable diesel produced from hydrogenation of soy oil by using two processes (renewable diesel I and II); and renewable gasoline produced from catalytic cracking of soy oil. We used four allocation approaches to address the co-products: a displacement approach; two allocation methods, one based on energy value and one based on market value; and a hybrid approach that integrates both the displacement and allocation methods. Each of the four allocation approaches generates different results.

Title:
Potential Energy and Greenhouse Gas Emission Effects of Hydrogen Production from Coke Oven Gas in U.S. Steel Mills

Authors:
Joseck, F.; Wang, M.; Wu, Y.

Publication Date:
January 2008

Venue of Availability:
International Journal of Hydrogen, 33, 1445 – 1454. Abstract available at http://www.transportation.anl.gov/pdfs/AF/528.pdf.

Content:
This study documents the development of the hydrogen production pathway from coke oven gas in GREET. We examined the energy and emission effects of hydrogen production from coke oven gas on a well-to-wheels basis and compared these effects with those of other hydrogen production options, as well as with those of conventional gasoline and diesel options.

Title:
Life-Cycle Energy Use and Greenhouse Gas Emission Implications of Brazilian Sugarcane Ethanol Simulated with the GREET Model

Authors:
Wang, M.; Wu, M.; Huo, H.; Liu, J.

Publication Date:
August 2008

Venue of Availability:
International Sugar Journal, Vol. 110, No. 1317. Abstract available at http://www.transportation.anl.gov/pdfs/AF/529.pdf.

Content:
In this study, the GREET model is expanded to include Brazilian sugarcane ethanol for use in both Brazil and the U.S. Results for sugarcane ethanol were compared with those for petroleum gasoline. The sugarcane-to-ethanol pathway evaluated in the GREET model is comprised of fertilizer production, sugarcane farming, sugarcane transportation, and sugarcane ethanol

production in Brazil; ethanol transportation to U.S. ports and then to U.S. refueling stations; and ethanol use in vehicles. Data sources for key assumptions of sugarcane ethanol pathways and their results are also presented.

Title:
Update of Distillers Grains Displacement Ratios for Corn Ethanol Life-Cycle Analysis

Authors:
Arora, S.; Wu, M.; Wang, M.

Publication Date:
September 2008

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. Available at http://www.transportation.anl.gov/pdfs/AF/527.pdf.

Content:
This report details the effort in updating the displacement ratios of dry milling corn-ethanol co-products used in the animal feed industry for use in the GREET model. Displacement ratios of corn-ethanol co-products including DGS, CGM, and CGF were last updated in 1998 at a workshop at Argonne National Laboratory on the basis of input from a group of experts on animal feeds. Production of corn-based ethanol (either by wet milling or by dry milling) yields the following co-products: distillers grains with solubles (DGS), corn gluten meal (CGM), corn gluten feed (CGF), and corn oil. Of these co-products, all except corn oil can replace conventional animal feeds, such as corn, soybean meal, and urea.

Title:
Well-to-Wheels Energy Use and Greenhouse Gas Emissions Analysis of Plug-in Hybrid Electric Vehicles

Authors:
Elgowainy, A.; Burnham, A.; Wang, M.; Molburg, J.; Rousseau, A.

Publication Date:
February 2009

Venue of Availability:
Research report, Center for Transportation Research, Argonne National Laboratory. ANL/ESD/09-2. Available at http://www.transportation.anl.gov/pdfs/TA/559.pdf.

Content:
This report examines the well-to-wheels energy use and greenhouse gas emissions of plug-in hybrid electric vehicles. The analysis incorporated fuel economy results from the Powertrain System Analysis Toolkit for PHEV and marginal electricity generation mixes from the Oak Ridge Competitive Electricity Dispatch Model. The WTW results were separately calculated for the blended charge-depleting and charge-sustaining modes of PHEV operation and then combined by using a weighting factor that represented the CD vehicle-miles-traveled share. GREET 1.8c.0 incorporates these changes for the simulation of PHEVs.

Title:
Simulation of the Process for Producing Butanol from Corn Fermentation

Authors:
Liu, J.; Wu, M.; Wang, M

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Content:
This study focuses on the simulation of a complete process for producing butanol via acetone, butanol, and ethanol corn fermentation. The simulation, which begins with grain processing and proceeds through product purification, represents the first attempt to simulate such a complete process. Energy use for the production process is highlighted and compared to that for the conventional corn ethanol process. The simulation results are utilized in a lifecycle assessment for butanol as a potential transportation fuel. The lifecycle assessment study is conducted using the GREET model. A variety of key parameters are examined, such as the state of the art of the unit operations included in the process and their key process parameters, as well as their effects on the total energy consumption and greenhouse gas emissions in the lifecycle of butanol.