Fuel GHG Pathways Update

January 30, 2009

California Environmental Protection Agency



Air Resources Board



Acknowledgement

- California Energy Commission
 - McKinley Addy
- Argonne National Laboratory
 - Michael Wang

University of California, Berkeley

- Michael O'Hare
- Andrew Jones
- Richard Plevin

University of California, Davis

Sonia Yeh

Purdue University

- Thomas Hertel
- Alla Golub
- Wally Tyner



CA-GREET and Fuel Pathways



Updated California-GREET Model

- New GREET model released September 2008 by ANL
- Updated CA-GREET model released Dec 2008 (modified by Life Cycle Associates)
 - LFCS inputs were changed individually for each pathway
 - All CI values reported here are in gCO₂e/MJ

Updated California-GREET Model (cont.)

- Updated 9 fuel pathways
- Created 5 new pathways (Sugarcane Ethanol, LNG, Soy Renewable Diesel, Farmed Trees Ethanol, and Forest Residue Ethanol)
- Latest documents do not reflect some minor CA-GREET model modifications and will be updated
- Remaining pathway documents will be published early February 2009



Changes in CA-GREET

- CH₄ and N₂O GWPs updated
- Heating value and carbon content of coal
- Regional electricity mixes used (CA, MW, etc.)
- Updated shipping and transportation distances



Factors Leading to Changes for Gasoline and Diesel Baseline

Crude Recovery

- Updated CA crude mix analysis including TEOR
- Updated transport distances
- Updated fuel shares based on aggregate energy

Crude Refining

Electricity emissions updated

Tailpipe

EMFAC emission factors



Fuels	CI
CARBOB	95.86
CaRFG	95.85
ULSD	94.71

CaRFG is modeled as nominally 10% corn ethanol using 80% Mid-West average corn ethanol and 20% CA Dry mill wet DGS corn ethanol. For the Mid-West, we assume 95% dry mill DDGS and 5% dry mill wet DGS. Blending EtOH CI = 95.66 gCO2/MJ. CARBOB values are WTW inclusive of tailpipe emission factors **Factors Leading to Changes for Corn Ethanol**

Corn Production

 Decreased energy input and % fuel shares in corn farming

Ethanol Production & Transport

- Electricity emissions updated for MW and CA mix
- Eliminate medium duty truck in ethanol transport
- Credit now for 1lb DDGS = 1 lb of feed corn

LUC Analysis

iLUC of 30 gCO₂/MJ from GTAP analysis



Mid-West Corn Ethanol-Carbon Intensity (gCO₂e/MJ)

Source	Technology and Details	Fuel	CA-GREET	LUC	Total
	Dry Mill, DDGS	100% NG	68.40	30.0	98.40
Mid-West	Wet Mill	60% NG 40% Coal	75.10	30.0	105.10
	Dry Mill, WDGS	100% NG	60.10	30.0	90.10
	Dry Mill, DDGS	80% NG, 20% biomass	63.60	30.0	93.60
	Dry Mill, WDGS	80% NG, 20% biomass	56.60	30.0	86.60
Mid-West Ave.	80% Dry Mill (95% 20% Wet Mill	6 DDGS, 5% WDGS)			99.40



CA Corn Ethanol-Carbon Intensity (gCO₂e/MJ)

Source	Technology and Details	Fuel	CA-GREET	LUC	Total
	Dry Mill, DDGS	100% NG	58.90	30.0	88.90
СА	Dry Mill, WDGS	100% NG	50.70	30.0	80.70
	Dry Mill, DDGS	80% NG, 20% biomass	54.20	30.0	84.20
	Dry Mill, WDGS	80% NG, 20% biomass	47.40	30.0	77.40
	LCFS Corn Ethanol Ave (80% Mid-West Average and 20% CA Dry Mill WDGS)			20%	95.66



Sugarcane and Cellulosic Ethanol – Carbon Intensity (gCO₂e/MJ)

Source	Feedstock/ Technology	CA-GREET	LUC	Total
Brazil	Sugar Cane, Fermentation	27.40	46.0	73.40
Mid-West	Forest Residue, Gasification	22.20	0*	22.20

* Currently assumes no Land Use Change impacts

1/29/2009



Factors Leading to Changes for H₂

- Electricity GHG intensity affects compression and liquefaction
- Fixed formula for efficiency
- Added compression step to liquid H₂
- On-site reformation scenario provided
- SB1505 scenario added



H₂ – Carbon Intensity (gCO₂e/MJ)

Fuels	Feedstock	Technology	CA- GREET	With EER= 2.3 for LDVs
H ₂ (liquid)	NG	Central Reforming	133.00	57.83
	NG	Central Reforming Liquid Delivery	142.20	61.83
H ₂		Onsite Reforming	98.30	42.74
(gaseous)	NG + Renewables	Onsite Reforming (compliant with SB1505)	76.10	33.09

Factors Leading to Changes for Electricity

Electricity

- Fixed error in earlier CA-GREET model
- Added marginal power generation scenario
- Marginal includes all combined cycle natural gas generation with 21.3% new renewables

Electricity- Carbon Intensity (gCO₂e/MJ)

Fuels	Feedstock	CA-GREET	With EER= 3.0 for LDVs
Electricity CA Ave.	CA Ave. Mix	124.10	41.37
Electricity, Marginal	NG	104.70	34.90



CNG - Carbon Intensity (gCO₂e/MJ)

Fuel	Feedstock	CI
CNG	CA Ave. NG	68.00
CNG	Land Fill Gas (Bio- methane)	11.40