REL National Renewable Energy Laboratory **Innovation for Our Energy Future**

A national laboratory of the U.S. Department of Energy Office of Energy Efficiency & Renewable Energy

Ethanol Production, Distribution, and Use Discussions on Key Issues

Rocky Mountain Fleet Managers Association 5-14-08

Gerry Harrow National Renewable Energy Laboratory





Today's Topics

- Ethanol Basics
- Flexible Fuel Vehicles (FFVs)
- Energy Balance
- Supply and Price Impacts on Food
- Land Use
- Water Use
- Emissions
- Tools and Resources



Ethanol Production

2006 Capacity: 4.9 billion gal/year

(96.1% using natural gas as energy source with 2% coal, 1% coal and biomass, 1% syrup)

EPA, EPA420-D-06-008

January 2008 Capacity: 7.9 billion gal/year at 139 biorefineries RFA, 1/2008

Projected Future Production Capacity: 13.4 billion gal/year (online and under construction) RFA, 1/2008

Current Gasoline Usage: 141.8 billion gallons/year or 388.6 million gal/day





Dry Mill Production Efficiencies 2001-2006

- Ethanol Yield: 16.4% per bushel
- Total Energy Use: ↓ 21.8%
- Grid Electricity Use: ↓ 15.7%
- **CO**₂ **Collection**: ↑ 23.5%
- Consumptive Water Use: ↓ 26.6%

Analysis of the Efficiency for the U.S. Ethanol Industry 2007, Argonne National Laboratory, 3/2008



Cellulosic Ethanol Production

Schematic of a Biochemical Cellulosic Ethanol Production Process



Recent Awards

\$4.1 million, USDA, woody biomass development

\$18.4 million over three years; DOE/USDA; biomass research, development and demonstration projects\$33.8 million over four years, DOE, further development of commercially viable renewable fuelsUp to \$86 million over four years, DOE, support development of small scale cellulosic biorefineries



Ethanol Fuels

- E10: Uses existing vehicles and infrastructure
- **E85:** Used in FFVs and requires specialized infrastructure
- E15-E20: Not a legal fuel except for use in FFVs. Currently being explored for non-FFVs



How are FFVs different?

Engine calibration updates: Fueling and spark advance calibrations directed by vehicle computer and software to optimize combustion, enable cold start, and meet emissions requirements

Piston rings: Special materials used to minimize wear from ethanol's alcohol properties, which wash lubrication from parts

Cylinder heads, valve seats, and valves: Special materials used to minimize wear from ethanol's alcohol properties, which wash lubrication from parts

Fuel sensor: Automatically senses 4 the composition of fuel to adjust for ethanol blends

> Fuel injectors: Made from ethanolcompatible materials; designed to deliver greater fuel volume required by ethanol's lower energy density

Insulated wiring: Made from special materials to handle ethanol's Increased conductivity and corrosiveness Fuel pump assembly: In-tank components made from ethanol-compatible materials; larger capacity fuel pump to deliver more fuel to compensate for ethanol's lower energy density

> Fuel filler neck: Anti-siphon and spark arrestor features included to meet U.S. regulations

Fuel rail and fuel lines: Made from ethanolcompatible materials; designed to handle increased fuel volume requirements to compensate for ethanol's lower energy density Fuel tank: Composed of special materials to minimize evaporative emissions from ethanol

www.eere.energy.gov/afdc/pdfs/42953.pdf



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Current FFV Population



There are currently more than 6 million FFVs on U.S. roads.



2008 MY FFV Availability

	Model Year	2008: Alternati	ve Fuel Vel	nicles and Advan	ced Technolog	gy Vehicles	
Fuel Type	Model	Vehicle Type	EPAct Compliant	Emission Class	Powertrain	Fuel Economy ^{1,2} (Alternative Fuel)	Fuel Economy ^{1,} (Gasoline)
		Ame 888	rican Hond	a Motor Corporat	ion		
CNG		000	cononda	ILEV. AT-PZEV.			
Dedicated	CMIC GX	Compact Sedan	Yes	Tier-2 Bin 2	1.8L.V4	24/36 mpgge	N/A
(NIMH)	Civie Hybrid	Compact Sedan	No	SULEV, AT-PZEV	1.3L CVT V4	N/A	40/45
Hydrogen Fuel Cell	FCX ⁸	Compact Sedan	Yes	ZEV, Tier-2 Bin 1	107 hp AC synchronous electric motor	62/51 mpkg	N/A
		10000000	C	hrysler			
		800-99	9-FLEET / w	ww.fleet.chrysler	r.com		
E85 FFV	Chrysler Sebring	Sedan	Yes	LEV IL Tier-2 Bin 8A	2.7L V8	13/20	18/27
E85 FFV	Dodge Avenger SXT	Sedan	Yes	ULEV	2.7L V8	13/19	18/26
E85 FFV	Chrysler Aspen	SUV	Yes	LEV II, Tier-2 Bin 8A	4.7L V8	9/12	14/19
ESS FEV	Dodge Durango	Light, Data Picture	Ves	LEVIL TIR-2 BIT SA	4.71.108	10/16	14/19
E85 FEV	Dodge Dakota	Light-Duty Pickup	Yes	LEVIL Tier-2 Bin 8A	4.71. V8	12/16	13/17
LOUTTY	Lodge Ham 1500	Cigrie-Duty Prickup	Tue	LEV II, THEFE DELON	4.72.90	Tak IS	13111
E85 FFV	Chrysler Town & Country Dodge Grand Caravan	Minivan	Yes	ULEV, Tier-2 Bin BA	3.3L V6	11/17	17/24
E85 FFV	Jeep Commander ⁴	SUV	Yes	LEV II, Tier-2 Bin 10A	4.7L V8	9/13	14/19
E85 FFV	Jeep Grand Cherokee*	SUV	Yes	LEV II, Tier-2 Bin 10A	4.7L V8	9/13	14/19
	÷	· · · · ·	Ford Mo	tor Company	8.		
	80	0-34-FLEET / v	www.fleet.fo	ord.com www.for	dvehicles.con	n	
E85 FFV	Crown Victoria Crown Victoria Police ²	Sedan	Yes	LEV II, Tier-2 Bin 5	4.6L V8	11/16	15/23
E85 FFV	Lincoln Town Car ^{3,4} Mercury Grand Marquis	Sedan	Yes	LEV II, Tier-2 Bin 5	4.6L V8	11/16	15/23
E85 FFV	F-150	Light-Duty Pickup	Yes	LEV. Tier-2 Bin 8A	5.4L V8	10/13	13/18
HEV	Escape Hybrid	SUV	No	SULEV II, AT-PZEV	2.3L ECVT V4	N/A	34/30
HEV (NIMH)	Mercury Mariner Hybrid	SUV	No	SULEV II, AT-PZEV	2.3L ECVT V4	NA	34/30
LPG	F-150 LPI	Light-Duty Pickup	Yes	TBD	5.4L V8	TBD	N/A
		(General Mo	tors Corporation			
		888-6	M-AFT-4U	www.gmaltfuel.o	com		
E85 FFV	Chevrolet Impala Chevrolet Impala Police ²	Sedan	Yes	LEV II, Tier-2 Bin 5	3.5L V6 3.9L V6	14/21	18/29
EB5 FFV	Chevrolet Tahoe Chevrolet Tahoe Police ³ GMC Yukon	SUV	Yes	LEV II, Tier-2 Bin 5	5.3L VB	11/15	14/20
E85 FFV	Chevrolet Suburban GMC Yukon XL	SUV	Yes	LEV II, Tier-2 Bin 5	5.3L V8	11/15	14/20
E85 FFV	Chevrolet Avalanche	Light-Duty Pickup	Yes	LEV II, Tier-2 Bin 5	5.3L V8	11/15	14/20
E85 FFV	Chevrolet Silverado GMC Sierra	Light-Duty Pickup	Yes	LEV II, Tier-2 Bin 5	5.3L V8	11/15	15/20
E85 FFV	Chevrolet Express GMC Savana	Light-Duty Van	Yes	LEV II, Tier-2 Bin 5	5.3L V8	9/12	12/16
E85 FFV	Chevrolet Uplander	Light-Duty Van	Yes	LEV II, Tier-2 Bin 5	3.9L V6	12/17	16/23
HEV (NIMH)	Chevrolet Malibu	Sedan	No	LEV II, Tier-2 Bin 5	2.4L Ecotec V4	NA	24/32
HEV (NIMH)	Satum Aura	Sedan	No	LEV II, Tier-2 Bin 5	2.4L Ecotec V4	N/A	24/32
HEV (NIMH)	Chevrolet Tahoe GMC Yukon	SUV	No	LEV II, Tier-2 Bin 5	6.0L Vortec V8	N/A	20/21
(NIMH)	Satum VUE Green Line	SUV	No	LEV II, Tier-2 Bin 5	2.4L V4	N/A	27/32

- 22 models available from five manufacturers
- Light-duty cars to full-size pickups and SUVs

Poet type	Model	Vehicle Type	EPAct Compliant	Emission Class	Powertrain	Fuel Economy ^{1,3} (Alternative Fuel)	Fuel Economy ^{ta} (Gasoline)
Lexus 800-255-3987 / www.lexus.com							
HEV	Lexus GS-450b	Sedan	No	SULEY	3.5LECVT V6	N/A	22/25
HEV	Lexus RX 4005	sov	No	SULEY	3.5L BOVT V6	N/A	27/24
HEV	Leaus LS 600h	Sedan	No	SULEY	S.OL BOVT VE	N/A	20/22
Mazda							
HEV	Tributer	SUV	No	SULEV IL AT-PZEV	2.3L BOVT V4	N/A	3400
Mercedes-Benz USA*							
ERS FFV	COOP Sport Sector	Sedan	Yes	ULEY	2.000ml	12/19	1605
			Nise	an USA*			
		800-1	ISSAN-1/1	www.niscanuca.c	som		
ERS FFV	Arrady	SUV	Yes	uev	5.6L VB	915	12/18
ERS PPV HEV	They'	Light-Duty Pickup	Yes	LEV	5.6L VB	913	12917
ONIMIO	Asima"	Secan	No	AS-P2EV	2.5L BOVT VM	N/A	203
			Toyota Mo	tor Sales, USA			
-		80	3-331-4331	www.toyota.com	10		
ONMIG	Prikas	Nic-Size	No	2 Bin 3	1.5L BOVT V4	N/A	48.45
ONMIG	Carry	Sedan	No	AT-P2EV	2.4L BOVT V4	N/A	33/34
HEV DIMID	Highlander	SUV	No	SULEV, Ten 2 Bin 3	3.5L BOVT V6	N/A	27/25
This vehicle is only This FEV model is This HEV model is Specifications have	available to fleet customers not available in California, C only available in select area inst been conferred by this sol available in California, N	onnecticut, Maine, Ma e of California. manufacturer for the S	saachusetta, Per	naşfranla, New Jersey, I	New York, Rhode Islan	d, and Vermont.	
This FFV model is n	This HEV model is only valiable in California, Connections, Manuachusette, New Jamey, New York, Rhode Island, and Vermont,						
This PPV model is n This HIEV model is	only valiable in California, C	ornecticut, Maire, Ma	New York, or Ve mashusetts, New	mont. • Jersey, New York, Rho	de Island, and Vermos	e	
This FFV model is a This HEV model is NG = Compressed IS = SYX Effance, OVT = Decharka DVT = Decharka	only valiable in California, C ed Technology Partial Zero I Natural Gas 15% Gasoline ly controlled Confinematly V metal Postection Agency	nare, Mostalare Berry, Jo consedicut, Malere, Ma Inflations Vehicle stable Transmission	New York, or Ve machinetts, Ne Giloscomy Io	mont. • Jense, New York, Sho • Abbi powiati Kong moge – miles per geto mole – miles per Kiego NBH – Nickel Metal Hy P2DV – Pastal Zeo B ULEV – Super Ulm Le	de Island, and Vermo Ine gallon equivalent on of hydrogen drife Assimut Vehicle we Emission Vehicle	r.	
This FFV readel is a This HEV model is NG - Compressed SS - 65% Chanol, DVT - Dectronical PA - U.S. Environ PV - Readels Facility EV - Hybrid Electro	only valiable in California, C di Technology Partial Zero I Hataral Gas 15% Gasoline ly controlled Continuously V mental Protection Agency Website (200 compatitie) is Vehicle	ara, Adentificat Maire, Ma Schollans Vehicle stable Transmission	New York, or Ve nadrovéh, Ne Giloscary o	vooti v Jaroney, Hww York, Bio F Abbirowin Lioma: mpoge – miles per Kiepe miles – Nickel Head Hig P2EV – Parkiel Zero Em SULV – Soper Ultra Li SUV – Spet Ultry Vick SUV – Spet Ultry Vick	de Island, and Vermon Res gallon equivalent ande data Materia Vehicle Ar Emission Vehicle de	a.	
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This PEV receives in This PEV - Advances R = Compressed RS = 60% Ebanosi, DVT - Electronic Facility $R = U.S. Environ RV - Photois Each EV - Hybrid Electric EV - Liber EV - Liber EV - Liber EV - Liber Environ$	only valiable in California, C ed Testandogy Factual Zeno (Natarati Gas 15% Casoline ly controlled Continuously V mental Protection Agency Webble (To compatible) is Vahida (To compatible) is Vahida w Endesign Vahida Netable	nere, was talonatered, organization convections. Vehicle principal Processitation	New York, or Ve machaneth, Ne Gilosscary (o	vort. v Jenney, Haw York, Rio (ADDross in Honord repose - miles per york mpdg - miles per kitage Nillet - Nichor Hensel Hy P2DV - Super Ultra Lo SULV - Super Ultra Vol SULV - Super Enterior V	de Island, and Vierson ine gallon equivalent on of hydrogen data islands Vehicle w Emission Vehicle d do on Vehicle is Department of Ener Hicle	5. DF	
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This PTV excells in This PTV excells in T-P2EV = Advances IN = Compression IN = Compression IN = Compression PA = U.S. Environ PV = Flasher Real PV = Particle Real EV = Liter CV = Liter Alterna www.eere.er U WWW.e	andy-statistics in Catheria, c. of Technology, Partial Zeol 15th Causain 15th Causa	Internetional Makes, Ma Interlane Vehicle stable Transvierion Interlane Solitons Solitons Solitons Solitons Solitons Solitons	Other	Prof. Versie, New York, Ros PADDraw In Storm PADDraw In Storm PADDraw In Storm PADDraw In Storm PADDraw In Storm Storm Pathol Storm Pathol Storm Pathol Storm Pathol Storm S	de Island, and Viernoo are gallon tophvalent are gallon tophvalent with with the second second texton Vielate de con Vielate es Department of Eren mice Fu Way Alformative	el Esonomy Guilo w fuelesonomy g Fuele & Advance Data Center	te jov d Vehioles

www.eere.energy.gov/afdc/pdfs/my2008_afv_atv.pdf



Existing E85 Infrastructure



www.eere.energy.gov/afdc/ethanol/ethanol_locations.html

There were 1,444 total E85 stations as of May 13, 2008.



Infrastructure Considerations

- There is currently no UL-certified dispensing equipment.
- Most jurisdictions allow alternate equivalent dispenser designs to be submitted for approval. Each jurisdiction has its own process and discretion in granting variances or waivers to approve designs not ULcertified.
- Firefighting technique is different. First responders must use alcohol-resistant foams.
- Federal and state incentives are available for alternative fuel infrastructure.



Do you get decreased fuel economy?

- E85 has 72%-77% of the energy content of gasoline (116,090 BTU/gallons for gasoline vs. 76,330 BTU/gallons for 100% ethanol). www.eere.energy.gov/afdc/fuels/properties.html
 - You would expect 23%-28% decrease in fuel economy from energy content difference
- FuelEconomy.gov shows FFV mpg ratings are 20%-36% lower for city and 20%-32% lower for highway than non conventional vehicles.
 - Fuel economy impact is model-dependent but shows decreases
- Ethanol's lower energy content by volume means more fuel is needed to get the same power. Power is limited by the volume of the fuel/air mixture that the cylinder can handle.



Does higher octane mean more power?

- Octane is a measure of auto ignition (detonation) resistance and is sometimes referred to as knock resistance
- Higher octane is beneficial in spark ignition engines designed for the higher octane
 - Increased combustion chamber compression
 - Supercharged or turbocharged
 - Bigger displacement
- Not a measure of deflagration (burn) or energy content



Ethanol Energy Balance

Most studies conclude that there is a net positive gain in life cycle energy when ethanol is produced from corn.

The amount of gain is greater when a cellulosic feedstock is used.



Ethanol Energy Balance



ANL, Ethanol, the complete energy lifecycle picture, 3/2007



Ethanol Energy Balance for Corn Ethanol



Ethanol Energy Balance

Btu required for 1 Btu available at fuel pump



ANL, Energy Balance of Gasoline and E85, 2007



Fossil Energy Ratio



Biodiesel data from "An Overview of Biodiesel and Petroleum Diesel Life Cycles", J. Sheehan, et al., 1998; J. Sheehan/M. Wang 2003



Factors Affecting Food Costs

- Higher Agricultural Commodity and Energy Prices
- Growth in Foreign Demand for Grains
- Reduced Foreign Competition and Supply
- Depreciating U.S. Dollar
- Buying of Grain and Oilseed Futures
- Weather, Drought



Factors Affecting Food Costs

- Less than one third of U.S. retail food contains
 corn as a major ingredient.
 Amber Waves, February 2008, USDA
- Corn exports increased from 53.9 metric tons in 2006/2007 to 63.5 metric tons in 2007/2008.

USDA, FAS, 5/2008

- Ethanol production and availability may have positively impacted fuel costs.
- "Across all food consumed, 30% higher corn prices increase all average food prices by 1.1%."

Center for Agricultural and Rural Development, Helen H. Jensen, Bruce A. Babcock, Iowa Ag Review, Summer 2007



Components of Retail Food Costs



Direct energy costs and transportation costs account for roughly 8% of retail food costs in 2005.

Main Street Economist, Vol. III, Issue I; 2008; Federal Reserve Bank of Kansas City

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Corn as Feed

- Feed Corn Usage
 - 2.6 lb of corn to produce 1 lb of chicken
 - 6.5 lb of corn to produce 1 lb of pork
 - 7 lb of corn to produce 1 lb of beef
- With corn at \$2.28/bushel (20 year average), 56 lb/bushel or \$.04/lb of corn, feed corn adds:
 - \$.10/lb of chicken
 - \$.26/lb of pork
 - \$.28/lb of beef
- Using the 2007 average price of corn of \$3.40/ bushel and assuming price increases would all be passed on to the consumer, prices would have increased:
 - \$.05/lb for chicken
 - \$.13/lb for pork
 - \$.14/lb for beef

Amber Waves, Vol. 6, Issue 1; USDA



NREL National Renewable Energy Laboratory

Corn Products for Human Consumption

- An 18-oz box of corn flakes contains approximately 12.9-oz of milled field corn
 - With corn at \$2.28/bushel (20 year average), 56 lb/bushel or \$.04/lb of corn, the corn value of the corn in this box is \$.033.
 - Using the 2007 average price of corn of \$3.40 and assuming price increases will all be passed on to the consumer, prices would increase by \$.016.
- A 2-liter bottle of soda contains approximated 15 oz of corn in the form of high-fructose corn syrup.
 - With corn at \$2.28/bushel (20 year average) the value of the corn is \$.038.
 - Using \$3.40/bushel prices would increase by \$.019.

Amber Waves, Vol. 6, Issue 1, USDA



Corn Farming Productivity



- Long-term trend for yield increase since 1940
- Acres planted generally decline or remain constant
- Fertilizer application increased rapidly until about 1980 then leveled off
- Yield increases continued unabated
 - Less fertilizer per bushel
 - Precision farming (GIS)
 - Improved crop strains
- Tillage has also been reduced



Farming Practices



Source: USDA, ERS, based on National Crop Residue Management Survey data from the Conservation Technology Information Center (CTIC).



- The primary ecological impacts of biofuels are in agriculture
- Significant economic incentives to farm with less inputs
 - Farm output per unit of energy down more than 50% in 60 years
 - Large growth (3x) in no-till farming
 - Data also show reduced use of pesticides and dangerous pesticides



Land Use

- 2007/2008: Out of the 86 million corn acres harvested, 21 million acres were used to produce approximately 6.5 billion gallons of ethanol.
- 2017/2018: Out of the 85 million harvested corn acres, USDA projects 28 million acres will be used to produce 4.9 billion bushels of corn for ethanol. This translates into approximately 13 billion gallons of ethanol using current published ethanol production yields (2.8 gallons/ bushel)

USDA Long-Term Agricultural Projection Tables, 2/2008; RFA Ethanol Industry Outlook 2008; USDA Amber Waves, 4/2006



EISA 2007 Renewable Fuel Standard

36 billion gallons of total renewable fuels by 2022

- 21 billion gallons of advanced biofuels
 - 1 billion gallons of biodiesel
 - 16 billion gallons of cellulosic biofuels
 - 4 billion gallons from any source
- 15 billion gallons from corn ethanol



Possible 2017/ 2018 Scenario

Assuming trends, farm legislation, weather, and crop yield growth continue to track as in the past and Conservation Reserve Program (CRP) land can be used for corn and perennials...

- Crop Residue: Cellulosic (Only 28% of land can have residual removed due to erosion concerns)
- CRP: Cellulosic (12 million acres out of 37 million acres in CRP)
- CRP: Corn (CRP acreage suitable for corn of 6.4 million acres)
- Corn (28.3 million acres)

Gallons Ethanol 9.4-12.2 billion 4.2-12 billion 2.6-3.1 billion 11.3-13.7 billion

Total for 2017/2018

27.5-42 billion

USDA Long-Term Agricultural Projection Tables, 2/2008; RFA Ethanol Industry Outlook 2008; USDA Amber Waves, 4/2006; USDA Amber Waves, 11/2007; USDA Agricultural Baseline Projections: U.S. Crops 2008-2017, 2/2008; ORNL, Biomass as Feedstock for a Bioenergy and Bioproduct Industry: The Technical Feasibility of a Billion-Ton Annual Supply, 4/2005, NAICC Annual Meeting Presentation, Hal Collins, USDA-ARS; NRDC Growing Biofuels: How Biofuels Can Help End America's Oil Dependence, 12/2004, EERE Biomass Program Web site



	Corn Use	
	2007/2008	2017/2018
Feed	45%	40%
Exports	19%	17%
Ethanol	25%	33%

USDA Long Term Agricultural Projection tables released 2/2008

Distillers grains from each bushel of corn used to produce ethanol substitutes for about a fifth of a bushel of direct corn feeding in livestock rations.

USDA Ethanol Expansion in the United States: How Will the Agricultural Sector Adjust? 5/2007



EIA's Annual Energy Outlook 2008 (March 2008 early release)

"Although the situation is very uncertain, the current state of the industry and EIA's present view of projected rates of technology development and market penetration of cellulosic biofuel technologies suggest that available quantities of cellulosic biofuels before 2022 will be insufficient to meet the new RFS targets for cellulosic biofuels, triggering both waivers and a modification of applicable volumes. ... The modification of volumes reduces the overall target in 2022 from 36 billion gallons to 32.5 billion gallons."



Water Usage

- 96% of field corn used for ethanol is not irrigated
- Water consumption for the other 4% is approximately 1.2 acre-feet of water per acre or approximately 785 gallons for every gallon of ethanol produced
- Water usage for ethanol production ranges from 3-4 gallons of water per gallon of ethanol produced.
- Future cellulosic production is estimated to use 1.9-6 gallons of water per gallon of ethanol
- Water usage for petroleum refining ranges between 2-2.5 gallons per gallon of gasoline

Water Usage for Current and Future Ethanol Production, Andy Aden, National Renewable Energy Laboratory, Southwest Hydrology, 9-10/2007



Price Impact on Gasoline

"The growth in ethanol production has caused retail gasoline prices to be \$0.20 to \$0.40 per gallon lower than would otherwise been the case."

The Impact of Ethanol Production on U.S. and Regional Gasoline Prices and on the Profitability of the U.S. Oil Refinery Industry, Working Paper 08-WP 467, April 2008, Xiaodong Du and Dermot J. Hayes, Center for Agricultural and Rural Development, Iowa State University

"Oil and gas prices would be about 15% higher if biofuel producers weren't increasing their output."

Francisco Blanch, Merrill Lynch, The Wall Street Journal, 3/2008

"The use of 10% ethanol blend saved Missouri drivers \$.077 per gallon at the retail pump in 2007."

Impact of Ethanol on Retail Gasoline Prices in Missouri, John M. Urbanchuk, LECG LLC, 4/2008



Global Factors Affecting Food Costs

- Global Grain Supply: \downarrow
- Global Grain Demand: 1
- Value of the Dollar: \downarrow
- Oil Demand: 1
- Buying of Grain and Oilseed Futures: 1



Global Grain Demand Increases

- Growth in foreign exchange holdings by major food importing countries (OPEC, Russia, Ukraine, China, Japan and other Asian countries)
- Protective policies by importers as food security measures
 - Reduced import tariffs and subsidies for consumers
- Biofuels
- Devaluation of the dollar, which may reduce importing costs
- Increased per capita income in developing countries, which increased per capita consumption of staples and diversified diet to include more meat and dairy
- Population Growth

Economic Research Service, USDA, WRS-0801, 5/2008

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Global Supply: Fewer Sources and Reduced Supplies

- Adverse Weather
 - Droughts in Ukraine, Russia, Turkey, Australia, and other countries
 - Decreased yields due to weather in other countries
- Protective policies by exporters to reduce food price inflation
 - Eliminated export subsidies, export taxes, quantitative restrictions, export bans
- Reduction in research and development focused on yield-enhancing technologies slowing production growth

Economic Research Service, USDA, WRS-0801, 5/2008



Grains as Food

 U.S. food supply: Nutrients contributed from major food groups, per capita per day, in 2004 were 23.5% from grain

USDA Center for Nutrition Policy and Promotion, 2/2007

- Percent of diet in low-income countries
 - Low-income Asian countries: 63%
 - Low-income North Africa and Commonwealth of Independent States: 60%
 - Sub-Saharan Africa: 50%
 - Latin America: 43%
 - Eritrea and Ethiopia: 70%
 - Bangladesh: 80%

Amber Waves, Vol. 6, Issue 1; USDA



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Ethanol Emissions

Well-to-Wheel GHG

- Decreases dependent on feedstock and energy source
- Tailpipe
 - Decreased NO_x , CO, benzene, butadiene, PM, and NMHC
 - Significant increases in formaldehyde and acetaldehyde
- Evaporative
 - E10 increases evaporative emissions in non FFVs
 - E85 lowers evaporative emissions

Other than EPA-certification data, there is limited current information available.

NREL National Renewable Energy Laboratory

GHG Emissions



ANL, Well-to-Wheels GHG emission Changes: Fuel Ethanol Relative to Gasoline, 2/2007

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California Energy Commission Comparison of Options for Reducing GHG and Petroleum Use



Fuel Cycle Assessment: Well-to-Wheels Energy Inputs, Emissions, and Water Impacts: Part of the State Plan to Increase the Use of Non-Petroleum Transportation Fuels; California Energy Commission, 2007; www.energy.ca.gov/2007public

NREL National Renewable Energy Laboratory

NO_x Emissions Comparisons of FFVs Using E85 vs. Gasoline



Effect of E85 on Tailpipe Emissions from Light-Duty Vehicles, McCormick/Yanowitz; accepted for publication in the Journal of the Air and Waste Management Association

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CO Emissions Comparisons of FFVs Using E85 vs. Gasoline



Effect of E85 on Tailpipe Emissions from Light-Duty Vehicles, McCormick/Yanowitz; accepted for publication in the Journal of the Air and Waste Management Association

NREL National Renewable Energy Laboratory

Effects on Tailpipe Emissions of Gasoline Used in FFV vs. Non FFV



Effect of E85 on Tailpipe Emissions from Light-Duty Vehicles, McCormick/Yanowitz; accepted for publication in the Journal of the Air and Waste Management Association



NREL Emissions Data Review

E85 versus Gasoline	Tier 1	Tier 2
in non-FFV:		
NMHC	-27%	
NMOG		-2%
СО	-18%	-42%
NO _x	-54%	-37%
PM	reduced	reduced
Formaldehyde	+56%	+13%
Acetaldehyde	+2000%	no data
Benzene	-86%	no data
Butadiene	-91%	no data

NREL



California Low-Emission Vehicle Program and FFVs

Excerpts from Alliance of Automobile Manufacturers Statement

- Emissions
 - Current vehicles have 99% fewer emissions than 1970s counterpart
 - E85-capable vehicles cannot meet CA LEV's SULEV standard
 - Expected that California will update 2008 program to so the average vehicle will have to meet the SULEV standard
- ZEV Mandates
 - 40% of vehicles sold in the state to certify to the ZEV standards
 - FFVs cannot meet the SULEV standards required
 - FFVs cannot meet the evaporative emissions in the PZEV category
 - To date, no FFVs have been certified to meet any of the ZEV standards
- CO₂
 - No practical way for automakers to get credit toward their fleet averages
 - Require proof that the vehicle is operating on E85



Where can I get more information?



Clean Cities

- DOE's Clean Cities
 - 86 coalitions bring local and regional resources together
- **Technical Assistance**
 - Industry and national laboratory experts for local implementation issues
- Puget Sound Red River Valley Capital Distric Columbia-Williamette Central New York Genesee Regio Granite State Twin Cities Mässachusetts Treasure Valley Western New York oque Valley Ocean State SE Area Detroit Connecticut NF Ohio Long Island Eastern Sierra Chicago e Ann New York City Pittsburgh Sacramento Regional Northern Colorado Arbor South Shore Philadelphia East Bay Delaware Central Indiana an Francisco San Joaquin Clean Kansas State of Maryland Valle Fuels Ohio Silicon Valley City Washington DC St. Louis Colorado Spring Commonwealth Hampton Roads Las Vegas Central Coast CC Partnership Antelope Valley SCAG Middle Los Angeles Tulsa Tennessee Central Western Riverside County Centralin East Oklahoma Long Beach Tennessee Central Palm Valley of Land of San Diego Region Arkansas Springs the Sun Enchantment Tucson Middle Dallas/Ft. Worth
 East Texas Georgia Baton Rouge Central Texas SE Texas Southeast Space Coast Alamo Area Louisiana Houston Galveston Connecticut Clean Cities Include Gold Coast - Norwich - New Haven **DOE Alternative Fuels** - Connecticut Southwestern Area **Data Center** Capitol Clean Cities of Connecticut Map Date - 04/08/08

Winnipeg

- Strategy Development ٠
 - National partnerships with industry, ____ manufacturers, etc., to enable local progress



Data and Tools

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- Technology- and User-Specific Tools to Support Implementation
 - Fleet Decision Tools
 - Cost Calculators
 - Fuel Implementation Resources



Data and Tools

- Alternative Fuels and Advanced Vehicles Data Center
 - Primary source of data on implementation of alternative fuels and more
 - Federal and state incentives, fueling station locations, available vehicles, industry resources
 - Averaging more than 1 million pages of information viewed per month



Resources

- NREL Web Sites
 - www.nrel.gov/vehiclesandfuels
 - www.nrel.gov/vehiclesandfuels/fleettest

DOE Web Sites

- www.eere.energy.gov/cleancities
- www.eere.energy.gov/afdc
- www.eere.energy.gov/vehiclesandfuels/epact
- www.eere.energy.gov/vehiclesandfuels/avta/index.html



Thank you!

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