Developing LCFS for Biofuels: Getting it right for Corn Ethanol

Kenneth G. Cassman
Heuermann Professor of Agronomy
Director, Nebraska Center for Energy Sciences
University of Nebraska

Adam Liska
Postdoctoral Fellow, University of Nebraska

Topics

- Purpose of LCFS
- Deployment timeframes for both biofuels and LCFS
- Importance of getting it right for corn-ethanol
- Biofuel Energy Systems Simulator

Purpose of LCFS

- 2007 Energy Independence and Security Act (EISA)
 - Help guide R&D prioritization & investment
- CA Low Carbon Fuel Standard
 - Achieve a 10% reduction in motor fuel GHG intensity by 2020
- Foster and reward the build-out of a "green" biofuel industry
 - GHG emissions trading, certification

2007 EISA definition: Life Cycle GHG Emissions

"(H) LIFECYCLE GREENHOUSE GAS EMISSIONS.—The term 'lifecycle greenhouse gas emissions' means the aggregate quantity of greenhouse gas emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes), as determined by the Administrator, related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gases are adjusted to account for their relative global warming potential.

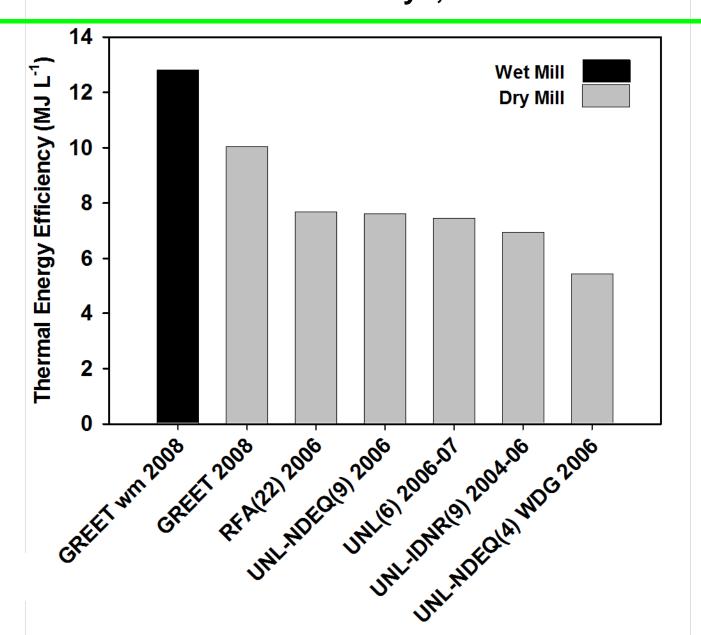
EPA Life Cycle Assessment Approach

- Domestic (FAPSOM) and international (FAPRI) agricultural sector models
 - Estimates land-use change in USA and globally
- GHG emissions derived from GREET and IPCC defaults
 - GREET includes carbon intensities for all petroleum-based and bio-based fuels

Need to get corn-ethanol right

- Rapid expansion of production capacity
- Actual data can be obtained for direct effects from crop production, ethanol conversion, and co-product use
 - Important to use values consistent with how the industry currently functions

Biorefinery thermal energy efficiency: Previous natural gas estimates vs. RFA & UNL surveys, NE & IA state records



Need to get corn-ethanol right

- Rapid expansion of production capacity
- Actual data can be obtained for direct effects from crop production, ethanol conversion, and co-product use
 - Important to use values consistent with how the industry currently functions
- Indirect effects difficult to estimate and highly uncertain
 - At what volume of production (15, 18, or 30 bgy?)
 - Currency exchange rates, land use policies, rate of yield gains on existing land?

2007 EISA renewable fuel standard mandate

YEAR	STARCH ETHANOL	ADVANCED BIOFUEL	TOTAL BIOFUEL
2008	9.0		9.0
2009	10.5	0.6	11.1
2010	12.0	1.0	13.0
2011	12.7	1.3	14.0
2012	13.2	2.0	15.2
2013	13.9	2.7	16.6
2014	14.4	3.8	18.2
2015	15.0	5.5	20.5
2018	15.0	11.0	26.0
2022	15.0	21.0	36.0

Corn-ethanol GHG emissions from different life-cycle models

Life-cycle GHG emissions intensity from dry-mill corn-ethanol (gCO2e/MJ)					
Emissions	GREET	EBAMM	BEACCON	BESS (1)	BESS (5)
Crop	44	37	44	30	33
Biorefinery	43	64	37	31	25
CP CREDIT	-17	-25	-17	-19	-24
Denaturant	_	_	6	-	-
Land use change	(104)	-	1	-	-
GWI	70	76	71	43	35
Gasoline	92	92	92	92	92
GHG reduction, %	24	17	23	54	62

GREET vs.1.8a: land use change from Searchinger et al. Science 2008

EBAMM: vs.1.1-1: Farrell et al. 2006, Science, "Ethanol Today" avg. ethanol plant in 2001

BEACCON vs.1.1: available from www.lifecycleassociates.com; largely based on GREET

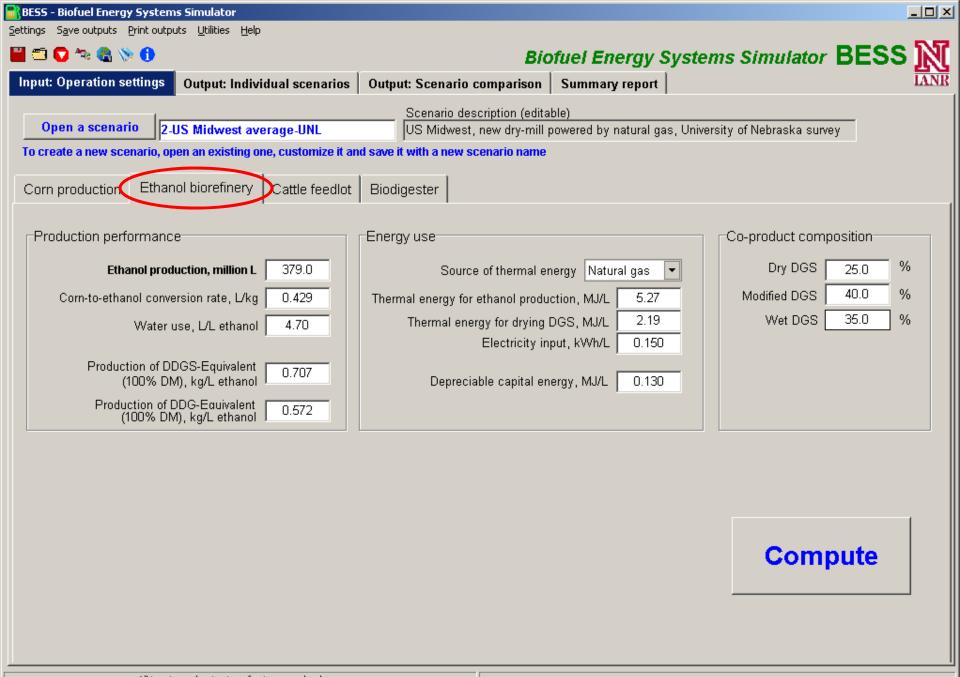
BESS: vs.2008.3.0: Scenario-1 Midwest avg. natl gas dry mill (RFA); Scenario-5 NE avg. natl gas with wet DGS BESS has a variable co-product credit which is dependent on the emissions intensity of crop production

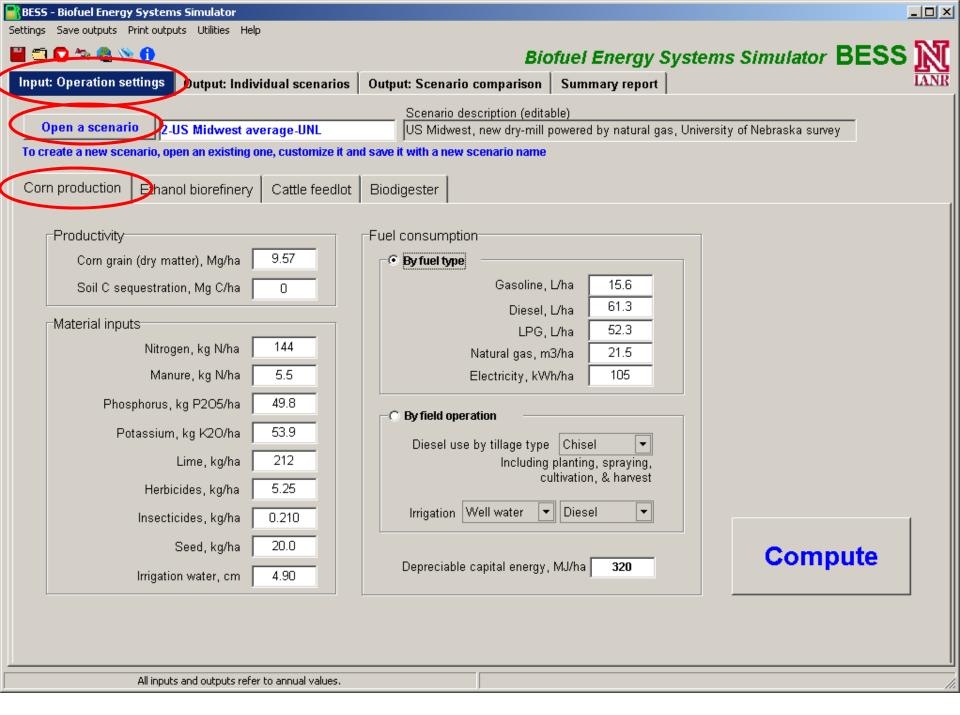
Biofuel Energy Systems Simulator (BESS) www.bess.unl.edu

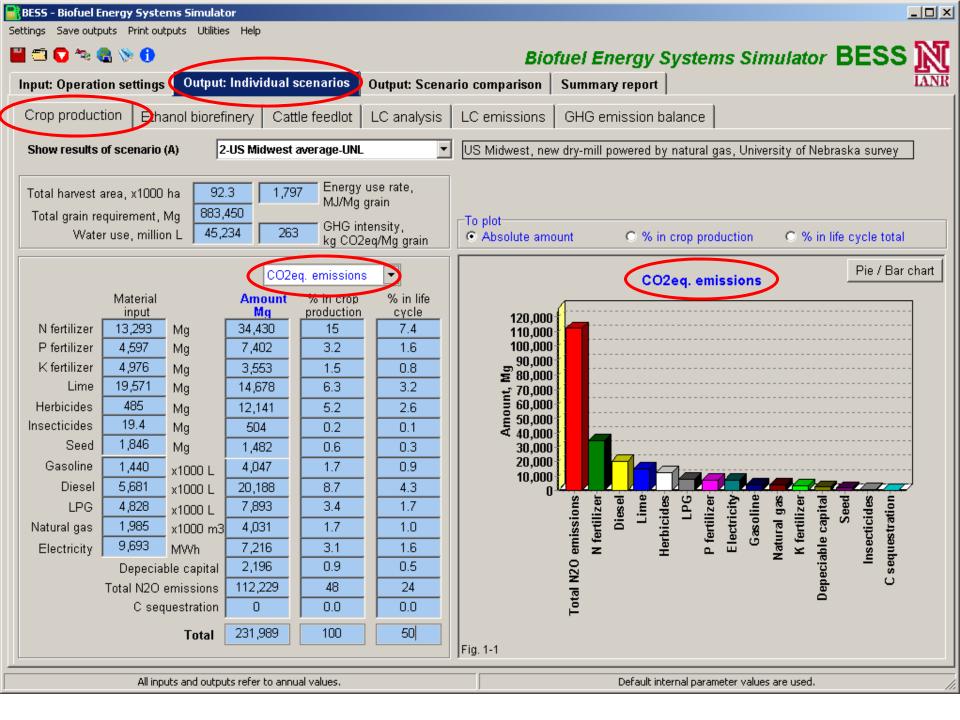
- Most up to date estimates for direct-effect GHG emissions for corn ethanol based on best current science and input from all key disciplines (engineers, agronomists, soil scientists, animal nutritionists, industry professionals)
- User-friendly, completely transparent, and well documented
- Default scenarios based on regional-scale data, but can also be used for certification of an individual ethanol plant, its associated corn supply and co-product use
- Can be used for estimating carbon-offset credits for emissions trading with an individual ethanol plant as the aggregator
- If GREET can be consistent with BESS for corn-ethanol GHG emissions estimates, then BESS can be used for compliance and certification

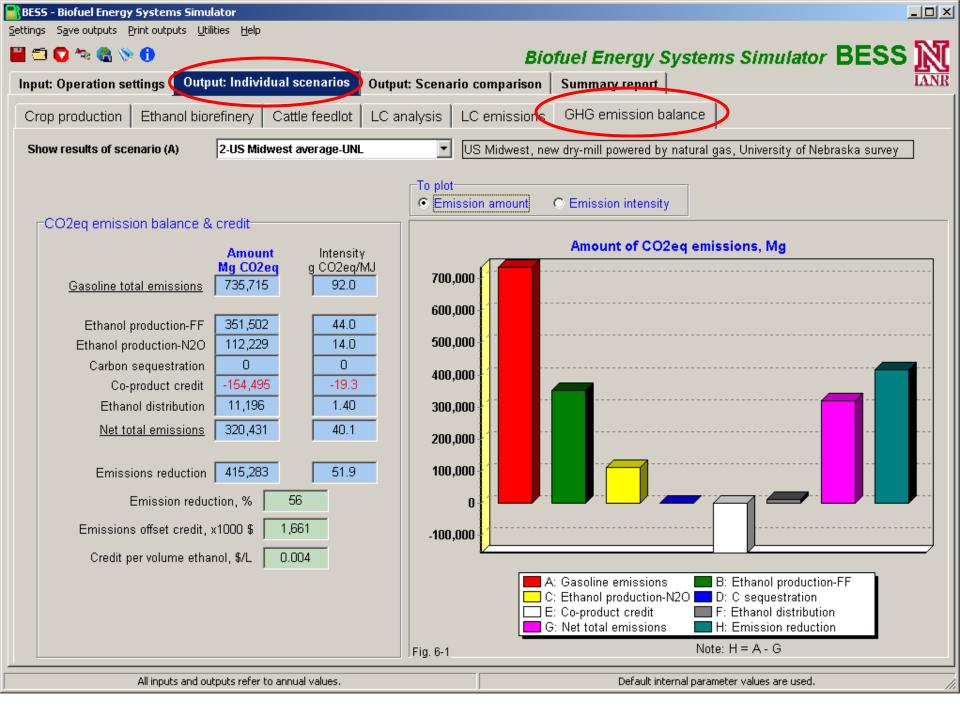
Default scenarios in BESS model: for different cropping regions and biorefinery types

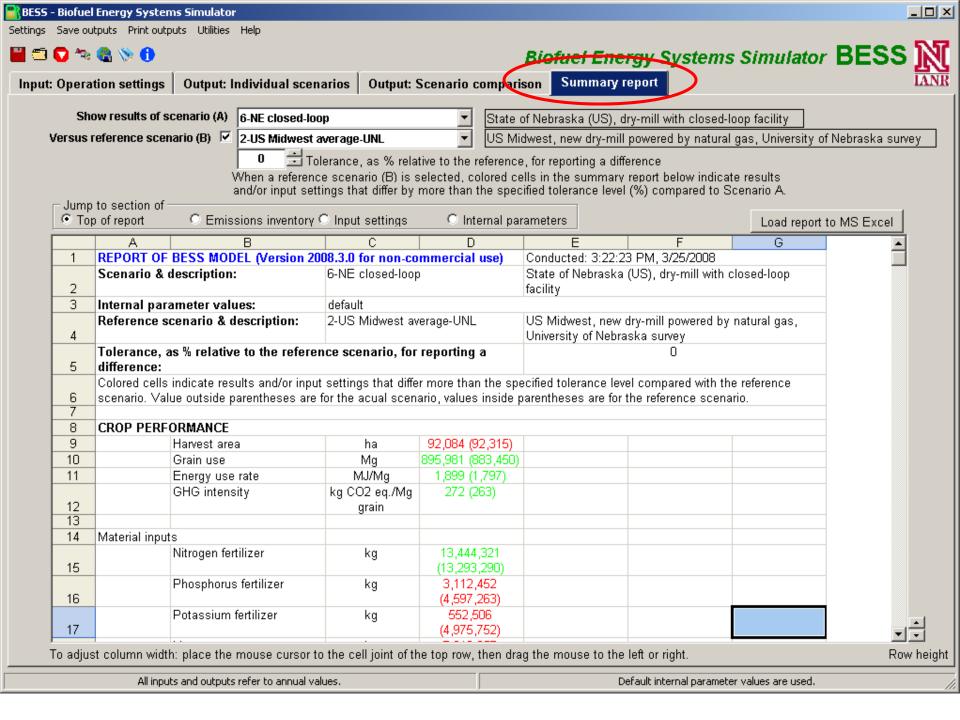
Scenario #	Crop production region	Biorefinery energy (dry mill)	Co-product type	NEW Survey Data
1	USA Midwest Avg.	natural gas-MW	mix dry-wet DGS	RFA-22
2	USA Midwest Avg.	natural gas-MW	mix dry-wet DGS	UNL-6
3	Iowa Avg.	natural gas-IA	mix dry-wet DGS	IDNR-9
4	Nebraska Avg.	natural gas-NE	mix dry-wet DGS	NDEQ-9
5	Nebraska Avg.	natural gas-NE	Wet DGS	NDEQ-4
6	Nebraska Avg.	NG, closed-loop	Wet DG	NDEQ-4
7	Nebraska Avg.	coal	Dry DGS	EPA
8	Progressive cropping (CSP)	natural gas-NE	mix dry-wet DGS	NDEQ-9











thanol Biorefineries

Influence of cropping system and biorefinery type on GHG emissions reduction: %, Mg CO2e*

20% reduction for 2007 EISA RFS

Corn Production System

	USA-MW	lowa	NE	Advanced
	average	average	average	Irrigated
coal	24%,	26%,	21%,	25%,
	179,000	187,000	153,000	186,000
natural gas†	54%,	57%,	50%,	55%,
	395,000	420,000	371,000	405,000
natural gas,	64%,	64%,	62%,	64%,
wet DG	469,000	468,000	444,000	474,000
closed-loop	72%,	72%,	68%,	73%,
facility	526,000	529,000	498,000	534,000

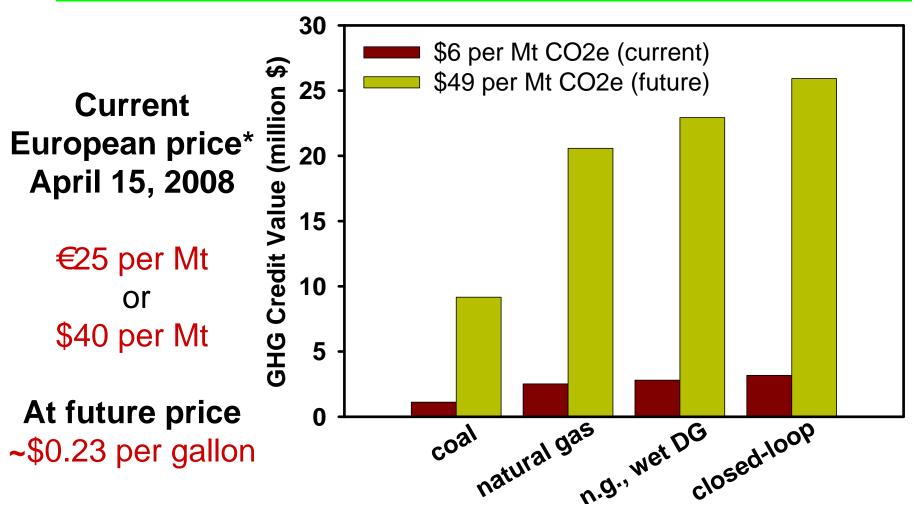
^{*}Based on a 100 million gal yr-1 production capacity, †average based on surveys

Our recommendation to California Air Resources Board: Create 3 classes of ethanol facilities for GHG regulation

- Title V permitted facilities; major source, e.g. 100 tons VOC/yr (includes all <u>wet mills</u> and <u>coal powered facilities in Nebraska and Iowa, 9 out of 31 facilities in 2006)
 </u>
- 2) Dry mills powered by natural gas (largest group)
- 3) Dry mills powered by natural gas, without dryers for DG (e.g. high cattle densities, closed-loop facilities, DG as energy source)

Class	I	II	III
Description	Title V (coal with Dry DG)	Natural Gas Dry Mills	N.G. Dry Mills w/ Wet DG
Thermal Energy, MJ L-1	12.81	7.61	5.44
BESS Life-cycle GHG emissions reduction	7%	51%	62 %

GHG emissions trading credit (cap-and-trade) for ethanol biorefineries according to type



^{*}www.pointcarbon.com; Chart results based on a 100 million gal yr-1 production capacity in IA; \$6 per metric ton CO2e, Apr. 15.2008, Chicago Climate Exchange, www.chicagoclimatex.com/ Future carbon price of \$49 per metric ton CO2e, pending *Climate Security Act of 2007* (Kintisch 2007); BESS.2008.3.0, www.bess.unl.edu

Sensitivity of input parameters on corn-ethanol carbon intensity:

The three most influential input parameters:

- 1. crop yield: Mg per hectare (+25% possible)
- 2. conversion thermal energy inputs: MJ per liter (+10%)
- 3. conversion yield: liters ethanol per kg grain (+7%)

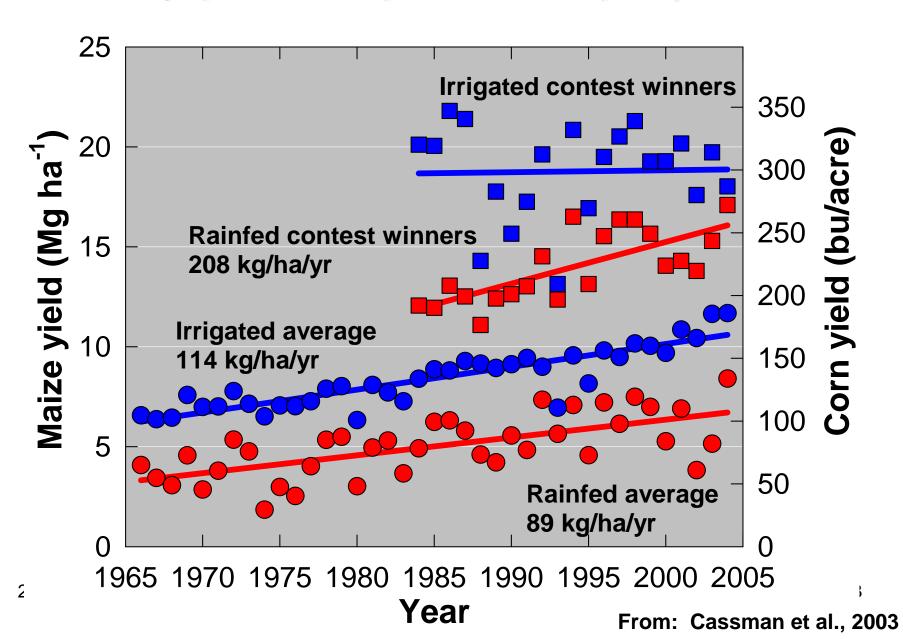
Next in importance:

- -wet versus drying distiller's grains
- -N fertilizer rate used in crop production

How to deal with indirect effects of land use change?

- One value for carbon "debt" from LUC applied to all USA corn-ethanol
- Key issues are:
 - Direct-effect GHG emissions starting point (50-65% reduction as estimated by BESS, or 24% as estimated by GREET in Searchinger et al (*Science*, 2008)
 - Volume of corn-ethanol production modeled by FAPRI/FASOM to estimate magnitude of land use change
 - Assumptions about rate of gain in corn yields
- What if there was a focused program to accelerate the rate of gain in corn yields while reducing GHG emissions per bushel produced?
 - A process called ecological intensification (*PNAS*, 1999)

Nebraska contest-winning vs average yield trends Average yields are only about 60% of yield potential!



CONCLUDING REMARKS

- Corn ethanol will be first to test the newly developed LCFS assessment methods; substantial amounts of other biofuels will come several years later
- Accurate valuation of direct-effect GHG emissions from corn ethanol is the foundation of the LCFS process; these affects vary with ethanol biorefinery type and corn feedstock supply
- Different reference GHG emissions values are needed for each major class of ethanol plants
- The BESS model provides the most up-to-date, scientifically sound estimate of corn-ethanol GHG emissions; can BESS and GREET reach agreement?
- Certification and compliance tools are also needed

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FREE download of BESS model: www.bess.unl.edu

 BESS model for CELLULOSIC ETHANOL from Corn residue and switchgrass, Summer 2008

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