Biofuel Land Use Issues: In Search of a Common-Sense Approach

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Global transition to a sustainable resource base: Defining challenge of our time

Land use issues & biofuels

Will have a dominant impact on the biofuels industry going forward

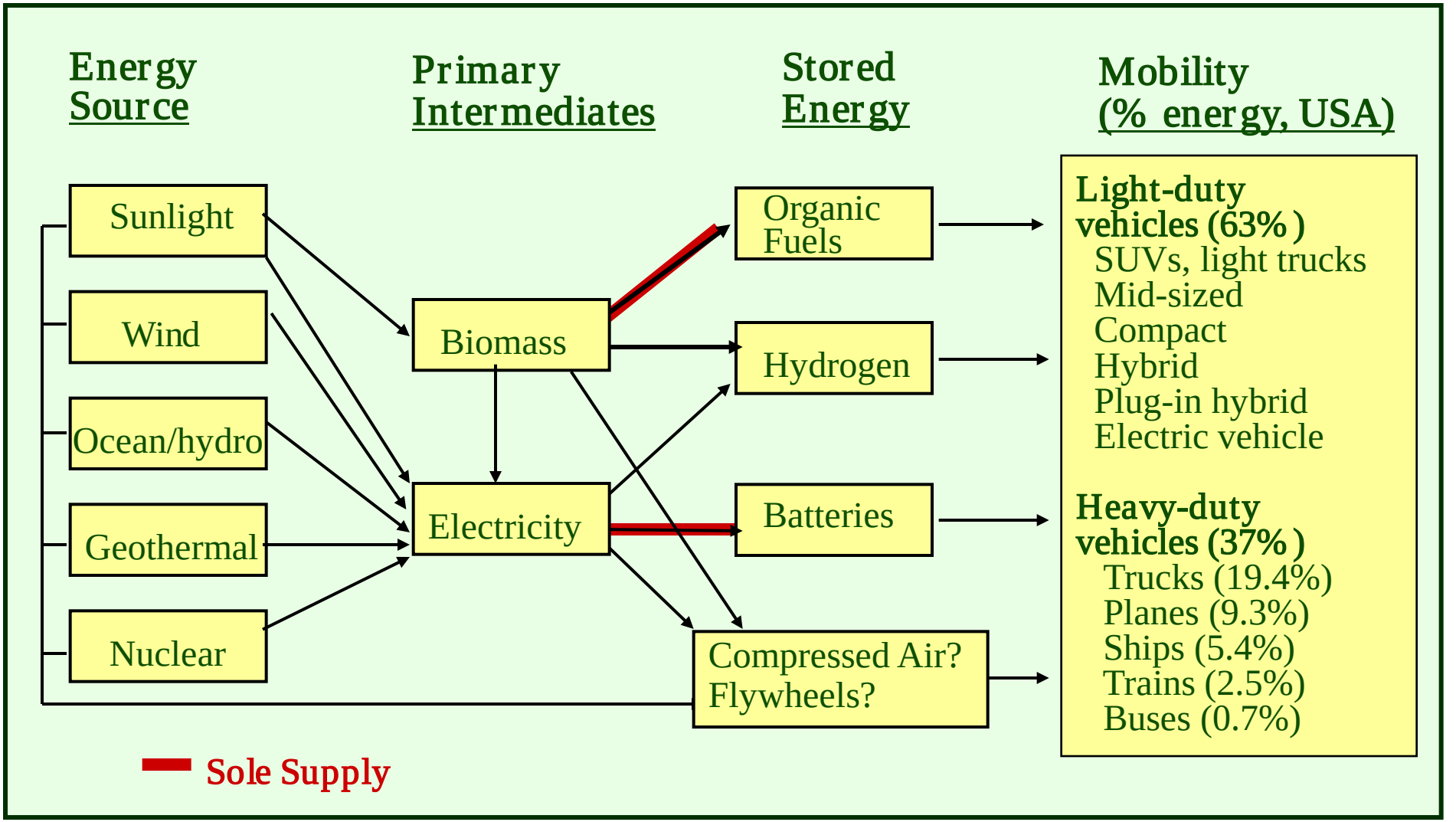
- Now: *Perceived merit* → policy support, investment
- Future: Scale, sustainability benefits attained

Many divergent opinions, no consensus on feasibility & desirability of biofuel production on a scale large enough to meaningfully impact sustainability & security challenges - say, 25% of global mobility

It has been suggested that we should forego the biofuel option because of land use challenges. A dispassionate response entails asking:

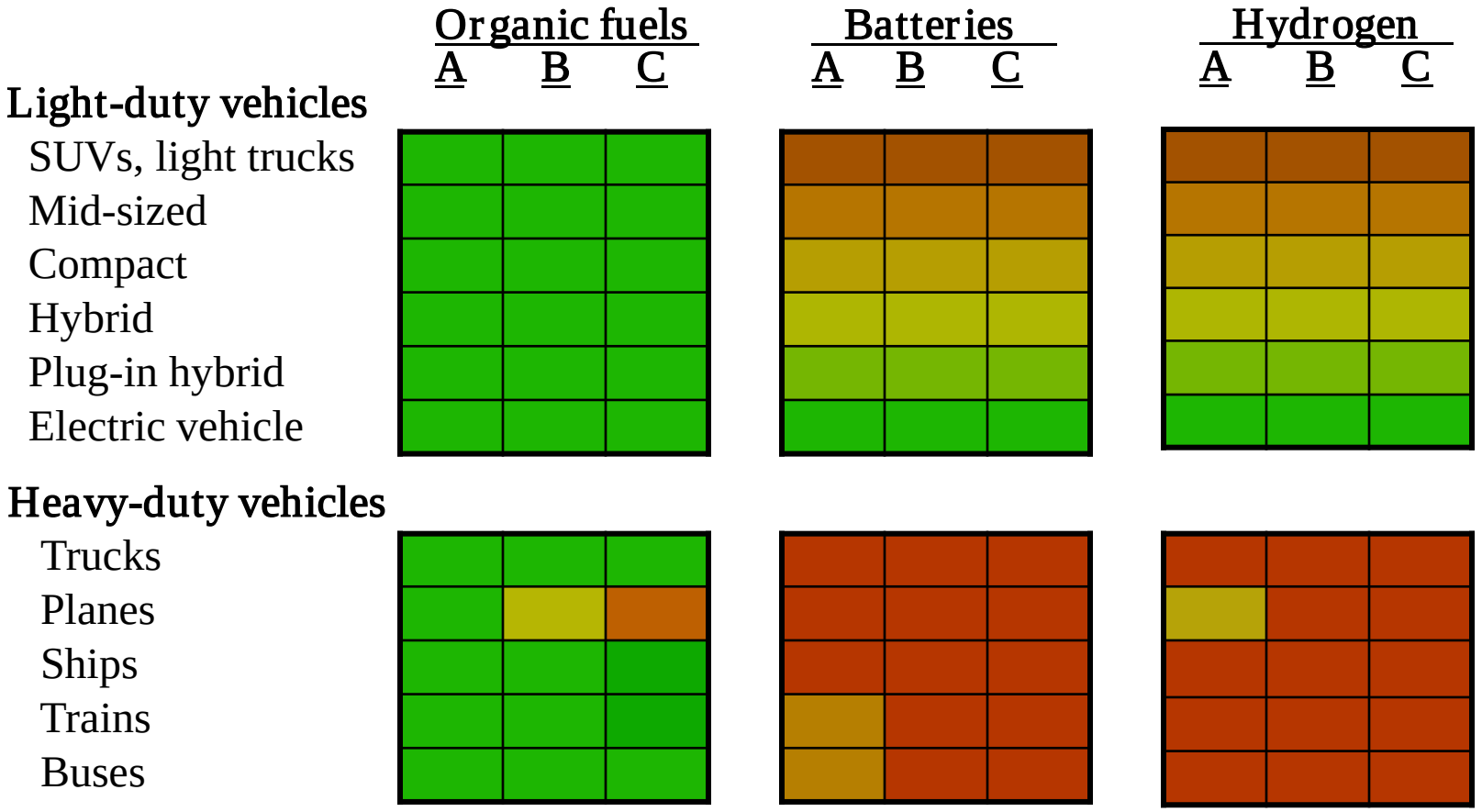
- What are our alternatives?
- What benefits would be missed?
- What are the prospects for gracefully resolving these challenges?

Sustainable Transportation Alternatives



Both innovation and change are required for all sustainable mobility options

Some vehicle-energy storage combinations are more feasible than others



- Electrification (batteries) impractical for most heavy duty applications
- Hydrogen faces many challenges, particularly if from low-C sources
- Even with extensive LDV electrification, organic fuels provide ≥ 50% mobility

Benefits missed if we forego the biofuel option

Energy security

Rural economic development

Environmental

- GHG emission reduction
- Reduced demand for unconventional petroleum (shale oil, tar sands)
- Increased use of low-carbon electricity to displace coal if less electricity needed for transport

Without biofuels, achieving a sustainable transportation sector is substantially more difficult and substantially less likely

Given these observations, it makes sense to approach with urgency the question:

Can biofuel land use challenges be resolved gracefully?

Dimensions of Innovation & Change Impacting Biofuel Land Requirements

Integrate feedstock production into managed lands *

- Double crops
- Coproduce feed and feedstocks - e.g. early-cut grass in lieu of soy, perhaps other strategies
- Increase harvest from underutilized pasture, range, and/or CRP land
- Sustainably harvest ag. residues, perhaps enhanced by new crop rotations
- Develop crop varieties with increased yields of non-nutritive cellulosic biomass (more residues)
- Sustainably harvest forest residues
- On abandoned, degraded, steep cropland

Produce food more land-efficiently

- Change animal feeding practices, e.g. pasture intensification, forage pretreatment
- Increase crop productivity, especially feed crops

Change diet *

- Amount & kind of animal products

Decrease fuel demand

- Energy efficient cars
- Public transportation
- Smart growth

Mature feedstock technology

- High productivity
- Broad site range
- Low inputs
- High digestibility

Mature conversion technology

- Advanced pretreatment
- CBP
- Advanced process engineering

LCFS impacts feedstock integration

***Will comment more on these…**

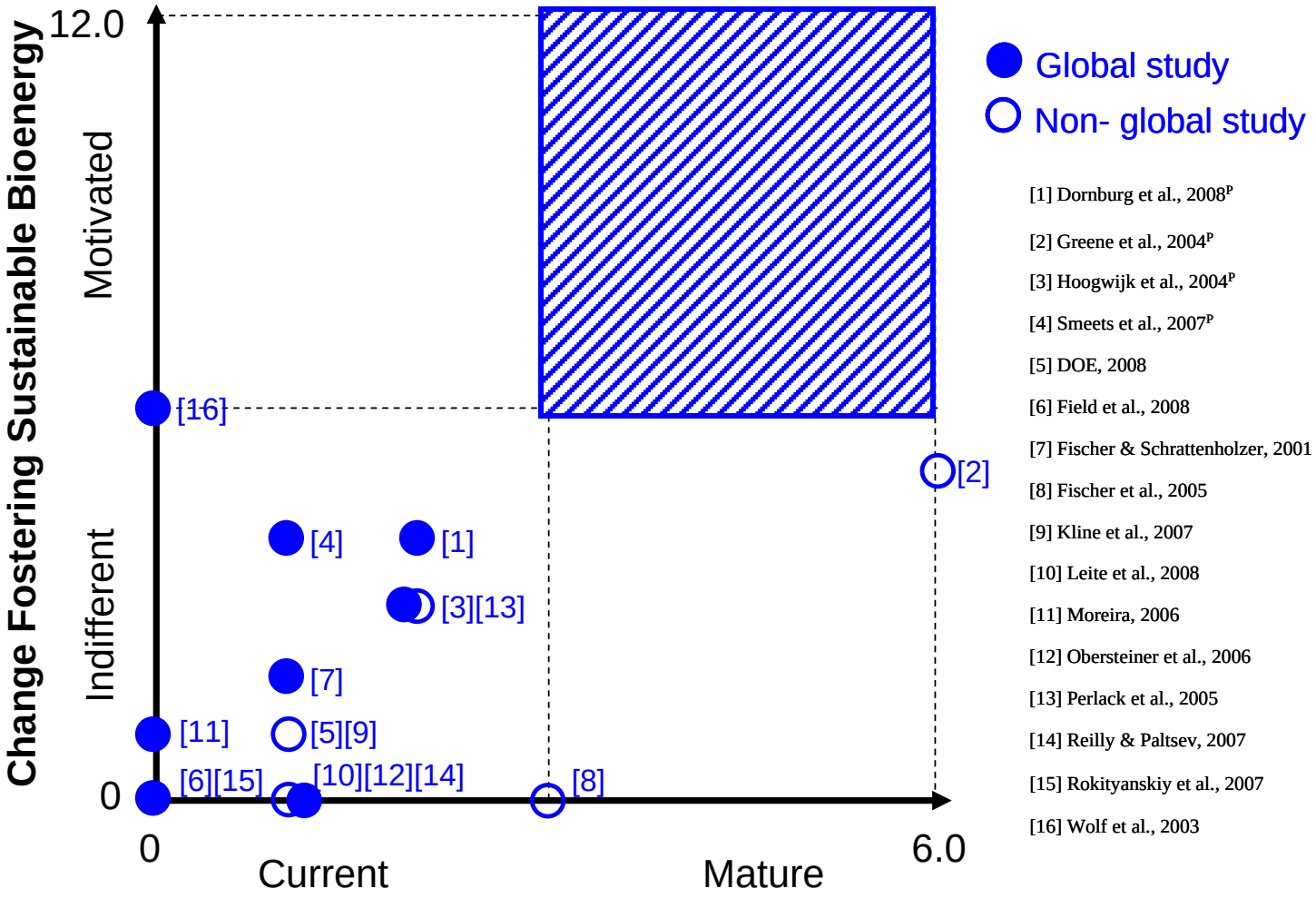
Consideration of Innovation & Change in Recent Studies Examining Biofuel Feasibility

	CHANGE TO ACHIEVE SUSTAINABILITY					TECHNOLOGY		
STUDY	Feedstock integration	Food production efficiency	Changing diet	Lower fuel demand	**Total**	Mature feedstock production	Mature cellulosic conversion	**Total**
Dornburg et al., 2008	1	2	0	1	**4**	2	0	**2**
Greene et al., 2004	2	0	0	3	**5**	3	3	**6**
Hoogwijk et al., 2004	1	0	1	1	**3**	2	0	**2**
Smeets et al., 2007	1	3	0	0	**4**	1	0	**1**
Leite et al., 2008	0	0	0	0	**0**	1	0	**1**
DOE, 2008	1	0	0	0	**1**	1	0	**1**
Field et al., 2008	0	0	0	0	**0**	0	0	**0**
Fischer et al., 2005	0	0	0	0	**0**	3	0	**3**
Fischer & Schrattenholzer, 2001	1	1	0	0	**2**	1	0	**1**
Kline et al., 2007	1	0	0	0	**1**	1	0	**1**
Moreira, 2006	1	0	0	0	**1**	0	0	**0**
Obersteiner et al., 2006	0	0	0	0	**0**	1	0	**1**
Perlack et al., 2005	1	2	0	0	**3**	2	0	**2**
Reilly & Paltsev, 2007	0	0	0	0	**0**	1	0	**1**
Rokityanskiy et al., 2007	0	0	0	0	**0**	0	0	**0**
Wolf et al., 2003	0	3	3	0	**6**	0	0	**0**

3 Extensive consideration
2 Moderate consideration
1 Minimal consideration
0 Not considered

Laser et al., in preparation

Consideration of Innovation & Change in Recent Studies Examining Biofuel Feasibility



Mature technology and motivation to solve energy challenges may seem optimistic, or improbable, but it is entirely unrealistic to expect to meet these challenges without both

Impact of Diet on Biofuel Production From Agricultural Land

Davis et al. (in preparation)

Diet Assumptions

↓ *DFL model*

Reduced Feed

↓ *DFL model*

Available Land

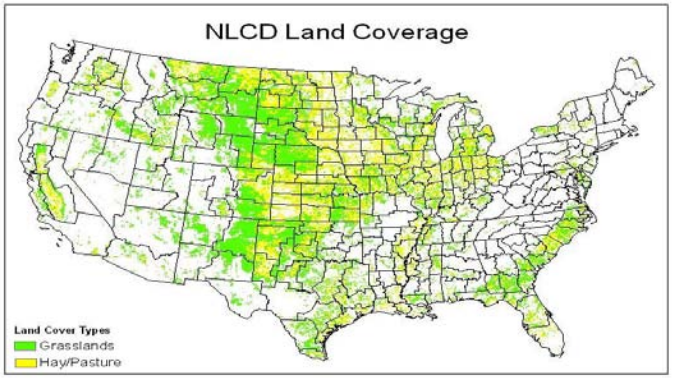
↓ *Biomass Productivity Model(s)*

Energy Crop Production

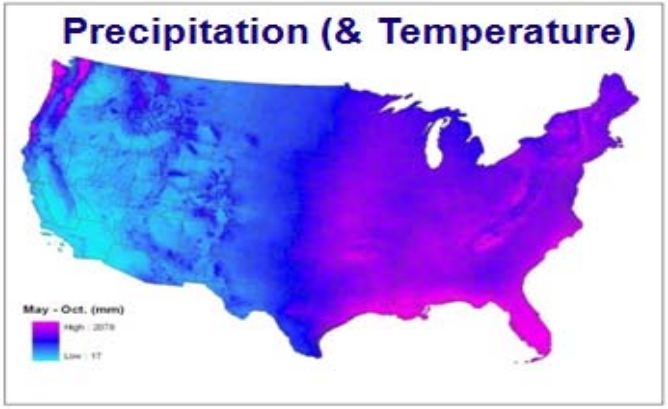
↓ *Process Yield*

Biofuel Production Potential

Portion of a given land-type



Climate Data for Liberated Land



In-progress analysis: Shifts in types of meat consumed could in some scenarios make available an amount of land with fuel production potential ***on the order of U.S. gasoline consumption****.*

Integrating Feedstock Production Into Currently-Managed Land

- **Food production is usually assumed to remain static**, or extrapolated, in analyses of biomass supply.
- Yet **new demand** for non-nutritive cellulosic biomass due to cost-competitive processing technology would likely bring **large changes**.
- Given a new value proposition, farmers would **rethink what and how they plant**.

Many options are possible.

Double cropping in Iowa
A. Heggenstaller, M. Liebman, R. Anex
US potential:
No protein displacement: 44 billion GGE*
With protein displacement: Larger

*Over the last century, the constant challenge in the world's functional breadbaskets has been supporting rural economies in the face of productive capacity exceeding demand - hence very **little policy or analytical effort has been devoted to feeding the world in a land efficient manner***

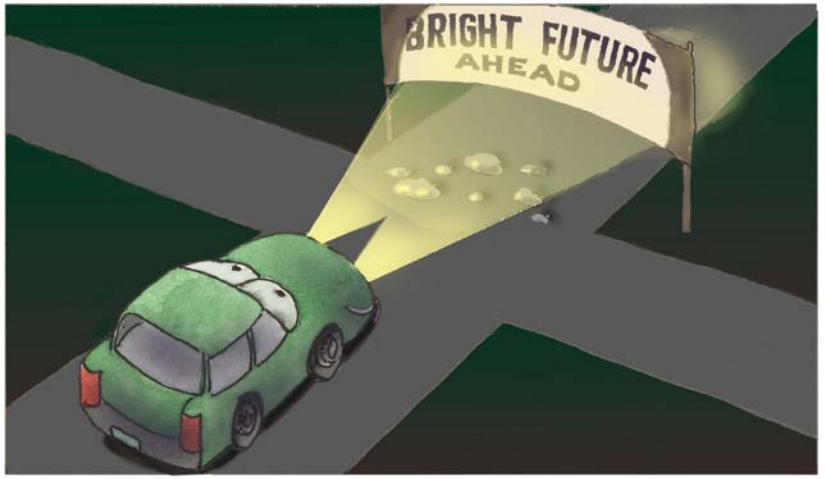
* GGE = Gallons gasoline equivalent; 240 mmacres*0.67*3 tons/acre*91 gal GGE/ton

Global Sustainable Bioenergy: Feasibility & Implementation Paths

Project initiated (June, 2009)

- International Organizing Committee formed
- Joint statement in *Issues in Science and Technology*
- Web site launched

Key Question: *Is it physically possible for bioenergy to meet a substantial fraction of future world mobility and/or electricity demand while our global society also meets other important needs.*



“High Beams” Approach

Staged structure

1. Meetings, assemble international team, scope project, get support
2. Address key question posed above
3. Policy, transition, equity, rural economic development issues

Global Feasibility of Large Scale Biofuel Production
Stage 1 Meetings & Organizing Committee

Representation	Host Institutions, Location	Meeting Chairs/ Organizing Committee Members	Dates
Asia, Oceana	PETRONAS Renewable Energy Laboratory, Kuala Lumpur, Malaysia	Reinhold Mann, Battelle Science and Technology, Malaysia	January 12-14 2010
European Union	Kluyver Center for Genomics of Industrial Fermentations, Delft, The Netherlands	• Andre Faaij, Utrecht University • Patricia Osseweijer, Delft University of Technology	February, 24-26, 2010
South America	University of São Paulo, São Paulo, Brazil	▪José Goldemberg, University of São Paulo ▪Carlos Henrique de Brito Cruz, FAPESP, São Paulo	March, 17-19, 2010
Africa	University of Sellenbosch, Stellenbosch, South Africa	• Emile van Zyl, University of Stellenbosch • August Temu, World Agroforestry Centre, Nairobi	March, 22-24, 2010
North America	University of Minnesota, Minneapolis/St. Paul, USA	• John Foley, University of Minnesota	May, 2010

http://engineering.dartmouth.edu/gsbproject

Two key hypotheses

- Biofuels are likely an obligatory part of a sustainable transportation sector
- Very large scale biofuel production can be gracefully reconciled with food production, and preservation of habitat and environmental quality

- **Somehow, the world has gotten this far without widely accepted consensus and clear understanding with respect to these**
- **It would be beneficial if this were to change**

Systemic, beneficial land use change and policies to motivate it

- Needed to avoid deforestation, with or without biofuels
- Needed for biofuels to be produced at levels required to meaningfully impact sustainability and security challenges, with or without addressing deforestation
- Yet not receiving much attention, often considered “out of bounds” by energy planners and policy makers
- LCFS impacts one of three land use levers, and one of six levers over all, that affect biofuel land requirements
- To motivate sustainable biofuels—likely required for a sustainable transportation sector—a broader policy approach is desirable