The Original Green - How Agriculture is Fueling the Green Economy

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The Original Green - How Agriculture is Fueling the Green Economy

Is agriculture contributing enough? Are you?
Maybe Not!!!
Thank you for your attention!
Any questions?
Agriculture in the Green Economy

• Bioenergy
• Renewable energy
• Energy conservation

• Opportunities and constraints
Some Issues to Consider

- National security
- Environmental quality
- Limited supply
- Increasing demand
A World Problem!

Peak Oil  (M. King Hubbert, 1956)

Liquid Transportation Fuel
A World Problem!

When oil demand outstrips faltering supply it creates a clash between energy haves and have nots.

(Matthew R. Simmons, Chairman Simmons & Company International)
Renewable Energy

- Massachusetts is now the second-leading clean-energy state in the U.S.

Massachusetts Clean Energy Center (MassCEC).
Energy cost of running to the Store

- Car gets 20 mpg travels 6 miles R/T.
- Purchase: 1 doz. Eggs, $\frac{1}{2}$ gal. Milk, & Bread.

- Unaccounted Energy: embodied energy in store, car, refrigeration, distribution, preparation, and waste.
Solar Renewable Energy
Why Biofuels?

• Fossil fuels take thousands of years to recycle carbon.
• Carbon from crops (switchgrass and corn) recycled in just one year, from wood a few years more.
Biofuel/Bioenergy Crops

• Biomass
  – Solid fuels (wood, grass pellets, corn grain)
  – Alcohol based fuels (grains, cellulosic)
  – Gasified fuels (cellulosic)

• Biodiesel
  – Crop oils (oilseed crops)
Farm Based Biofuels

Oilseed Crops

- Crambe
- Oilseed Rape/Canola
- Sunflower
- Soybean
Farm Based Biofuels
Annual Yields – 1-3 t/ac

Crambe

Oilseed Rape/Canola

Sunflower

Soybean
Cellulosic Biomass

Willow
Poplar

Switchgrass 5-9 t/ac

Corn
Stover
3 t/ac

Miscanthus giganteus - 26.5 t/ac observed Univ. of Illinois
Biofuel Energy: alternative crops on abandoned and non-productive land
Ethanol from Corn and Crop Residues

• Is this sustainable?
Ethanol Feedstocks

- Corn grain – 92 gal/ton; ~ 400 gal/ac
- Cellulosic – 90 gal/ton
  corn stover ~ 270 gal/ac
Ethanol Feedstocks

- Corn grain – 92 gal/ton; ~ 400 gal/acre
- Cellulosic – 90 gal/ton
  - Corn stover ~ 270 gal/acre
  - Switchgrass ~ 400 gal/acre

Both processes not very efficient.
## Oilseed Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>US gal oil/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflowers (30)</td>
<td>102</td>
</tr>
<tr>
<td>Oilseed rape (45)</td>
<td>150</td>
</tr>
<tr>
<td>(related to crambe)</td>
<td></td>
</tr>
<tr>
<td>Soybean (18)</td>
<td>75</td>
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</table>

**Constraints:** combines, oilseed press, technology

[http://journeytoforever.org/biodiesel_yield.html](http://journeytoforever.org/biodiesel_yield.html)
Efficiency of Biofuel Crops

- Switchgrass Pellets
- Switchgrass Ethanol
- Grain Corn Heat
- Grain Corn Ethanol
- Oilseed Rape

Recovery of Original Biomass Energy (%)

- 0
- 20
- 40
- 60
- 80
- 100
Eff. & Yield of Biofuel Crops

Switchgrass Pellets 80
Switchgrass Ethanol 60
Grain Corn Heat 40
Grain Corn Ethanol 20
Oilseed Rape 0

Energy Yield
Switchgrass 4.5 ton/ac
Corn 175 bu/ac
Oilseed Rape 1.8 ton/ac

Recovery of Original Biomass Energy (%)
0 20 40 60 80 100

Energy Yield (Bill. Btu/ac)
0 10 20 30 40 50 60 70 80
Net Energy Yield of Biofuels

- Switchgrass Pellets: 4.5 ton/ac
- Corn Ethanol: 175 bu/ac
- Oilseed Rape: 1.8 ton/ac
Cellulosic Biomass

Why switchgrass?
Switchgrass

- Low maintenance
Farm Forests

- Grow naturally
- On-farm and community heat
- Local and regional biomass
- Environmental considerations
Need to Invest in Appropriate Technologies

Thermochemical

- Gasification / Fast Pyrolysis
- Wide variety of feedstocks
- Scalable - low capital cost & relatively small footprint
Green Energy in Agriculture

1. Efficient processing technology.

2. Sustainable feedstock production and distribution systems.

3. Adequate profits along the value chain.
Renewable Energy
LAND AREA REQUIREMENTS
Electricity Consumption in MA = 53 million MWh
Total US Consumption = 3,150 million MWh

1.1 million ac
wind farm area
(class 4 wind)

5.3 million ac
State Land Area

147,200 ac
PV/BIPV

6.5 million ac
willow plantations

Adapted from:
Keoleian, UMich.
Lewis, UWaterloo
On-Farm Solar Options
Wind Power

• By 2020, wind could provide 12% of world electricity supplies. (European Wind Energy Assoc.)
• Denmark - 20% of electricity needs.
• U.S. only ~0.5%, potential for 10%.
Wind Power

- 'Non-firm' or 'intermittent' generation cited as a detriment.
- Capacity factor used of 30-35%.
- Is wind variability a major threat?
- Up to 10% of country's electricity can come from intermittent energy sources.
- Major States - Great Plains (top 10 states)
Off-Shore Wind Power

United States offshore wind resource at 90 m above the surface.

Wind Speed at 90 m

<table>
<thead>
<tr>
<th>m/s</th>
<th>mph</th>
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<tbody>
<tr>
<td>11.5 - 12.0</td>
<td>25.7 - 26.8</td>
</tr>
<tr>
<td>11.0 - 11.5</td>
<td>24.6 - 25.7</td>
</tr>
<tr>
<td>10.5 - 11.0</td>
<td>23.5 - 24.6</td>
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<tr>
<td>10.0 - 10.5</td>
<td>22.4 - 23.5</td>
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<tr>
<td>9.5 - 10.0</td>
<td>21.3 - 22.4</td>
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</tr>
<tr>
<td>0.0 - 6.0</td>
<td>0.0 - 13.4</td>
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Renewable Energy
Costs & Incentives - Moving Targets

Cost
Capital Cost 100 kW system @ $7 / Watt = $700,000
Less PTC\textsuperscript{f} Incentive = $210,000
Carrying Cost = loan for portion not funded by incentives
    Loan @ market rate for balance: cost for
    $490,000 @ 5.25, 10 years = $63,088/yr

Funding §
    $250 - $500 per kW annually (10 yrs) = $25K to $50K
Electric Savings: $0.17 to $0.34/kWh/yr = $17K to $34K
    Funds for loan payment $42,000 to $84,000
Net cost/benefit -$21,088 to +$20,912
Food System Energy Use

Production
- Planting
- Cultivation
- Irrigation
- Equipment
- Fertilizer

Processing

Transport

Retail/Food Service

Home

Source: Heller and Keoleian
Where We Use Energy in Crop Production

- Planting
- Pesticides
- Cultivation
- Equipment
- Irrigation
- Fertilizer

Production 21%

34% Direct fuel use
28% Fertilizer (mostly N)
7% Irrigation
31% Other (grain drying, facilities operation)
Reducing Farm Fuel Usage

• Reduce tillage, combine operations.
• Lower forage production cost, use pasture, haylage?
• Reduce fuel used in buildings (heat), recycle (burn) waste oil, use biofuels.
• Use bio-diesel alternatives.
Pasture Intensification: for lower energy input into feed for dairy and livestock
Only 4% of Haber-Bosch N in fertilizer produced and used in animal production enters the consumers mouth.
Fertility Conservation

• Change process of N fertilizer production.
• Control soil erosion, use cover crops, reduce tillage or use no-till.
• Proper timing, rates and incorporation of manure.
Off-Farm Food Energy Use - 79%

- Farm
  - Transport: 14%
  - Processing
    - Transport
  - Packaging: 23%
  - Retail/Food Service: 11%
  - Home Refrigeration Preparation: 31%
In 2001 the US imported:

- 68% of our fish and shellfish
- 27% of confectionary products
- 21% of fruits, juices, and nuts
- 16% of vegetable oils
- 9% of red meat
U.S. Imported Fresh Fruit and Vegetables

Source: USDA Econ. Res. Serv.
It is not the food we grow, it is more the food we do not grow!

Can we grow more food locally?
Food Miles

- Distance food travels from where it is grown to where it is consumed.
- Estimates range 1,500 to 2,500 miles.
- Food miles have increased much in recent years.
Food Miles vs. Buy Local Economic Opportunity

- Peaches grown in Spain.
- Shipped to Thailand for processing.
- Shipped to U.S. for distribution.
- Arrive in Massachusetts store for purchase.

Total Food Miles: >14,000
A Crude Oil Meal

- Bowl of oatmeal porridge: 4oz crude oil.
- Serving of red raspberries: 1oz crude oil.
- Butter, milk and salt: 1oz crude oil.
- Cup of java: 2oz crude oil.

Energy in one week's worth of breakfast for one person: More than 2qts of crude oil.

Chad Heeter, San Francisco Chronicle
Is Local Field Production Enough?

1000 cwt

Spinach
Strawberry
Lettuce
Tomato
Apple

Outside NY State, US
Outside NY, Foreign
Inside NY State
All Used in NY

1000 cwt
Livestock

- Meat and dairy: 50% of all food-related emissions of CH₄, N₂O, and CO₂.
- Animal-based protein foods 2-100 times more energy intensive than plant-based.
- Plants <1 GJ in/GJ out
- Animals >8 GJ in/GJ out
Processing & Transport of Crops

Kg CO2 equiv./600g serving

Carrots

Fresh Bunched
Fresh Peeled
Frozen Bag
Canned (landfill)
Pouch
Laminate Carton

Carrots
Impact of Food Transport
CO$_2$ Emissions and Miles Traveled

Conventional System

Regional System

Local System
CSA/farmers markets, institutional markets
CO$_2$ Emissions and Miles Traveled

368,000 gal/yr
8,400,000 CO$_2$ lbs/yr

44,000 gal/yr
993,000 CO$_2$ lbs/yr

88,000 gal/yr
1,730,000 CO$_2$ lbs/yr
Agriculture in the Green Economy

**Energy Crops:**
- Heat (grass pellets, corn grain)
- Biodiesel (oilseed crops)

**Renewable Energy:**
- Photovoltaic dual land use

**Energy Conservation:**
- More local food
- Less processed food
Thank you

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