Energy Smart Farming

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Why Reduce Fossil Fuel Use?

• Environmental reasons
  – Reduce carbon emissions
  – Reduce impacts of fossil fuel extraction and burning

• Economic reasons
  – Reduce input costs (sometimes…)
    • Energy typically ~10-15% of farm costs
  – Reduce risk; enhance security, independence

• Prepare for energy-constrained future
KY Energy Consumption, 1960-2025

Data from DOE-EIA, 2008
Onion (t/ha)
Potato (t/ha)
Grain corn (t/ha)

US farmland (10^7 ha)
US farm population (10^6)

Direct and indirect energy use (10^{17} J)
Direct energy use (10^{17} J)

Changing face of US agriculture
Land, labor and energy

- For 30 years US farmers have been making more efficient use of labor, land, and energy
- US farmers tend to use more land and less labor than farmers in other parts of the world
- US farmers tend to use less energy than farmers in other industrialized countries, but more energy than farmers in developing countries
Total Energy Consumed on US Farms, 1965-2002

- Fertilizers and pesticides
- Gasoline
- Diesel
- LP gas
- Natural gas

Quadrillion BTUs

John Miranowski, Iowa State University
US Food System
Energy Use, 2002

- Non-food: 85.6%
- Food: 14.4%
- Agriculture: 2.0%
- Processing: 2.8%
- Packaging: 0.9%
- Wholesale & retail: 2.2%
- Transportation: 0.6%
- Food service: 1.7%
- Households: 4.1%

## Proportion of national energy use

<table>
<thead>
<tr>
<th>Country, year</th>
<th>Agriculture (direct &amp; indirect)</th>
<th>Food system</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA, 1996</td>
<td>2.1%</td>
<td>10%</td>
<td>Heller &amp; Keoleian. 2000. Life Cycle-Based Sustainability Indicators for Assessment of the U.S. Food System</td>
</tr>
<tr>
<td>UK, 2005</td>
<td>1.9%</td>
<td>11%</td>
<td>White. 2007. Carbon governance from a systems perspective: an investigation of food production and consumption in the UK</td>
</tr>
<tr>
<td>USA, 2002</td>
<td>2.0%</td>
<td>14%</td>
<td>Canning et al. 2010. Energy Use in the U.S. Food System. USDA-ERS Report #94.</td>
</tr>
</tbody>
</table>
Agriculture:
Small piece of energy pie

- ~15% of food system energy use
- ~2% of national energy use (industrialized)

Exceptions:

- More intensive:
  - Livestock (especially cattle)
  - Heated greenhouses
  - Plasticulture

- Less intensive:
  - Organic
  - Grain
  - Small farms?
Red meat & dairy account for most food GHG emissions in US

- Mostly production, not transport
- Mostly CH\(_4\) and N\(_2\)O
- Mostly not energy related

Energy use accounts for most greenhouse gas emissions in most of the economy... not so for agriculture!
Soil management, ruminant digestion & manure management account for most non-energy GHG from agriculture.

Agricultural Soil Management: 216 Tg CO₂ Eq.
Enteric Fermentation
Manure Management
Rice Cultivation
Field Burning of Agricultural Residues

Agriculture as a Portion of all Emissions: 6.1%
Goals:
1. Net energy production
2. Net C sequestration

Realistic, achievable

- Many successes in past 30 years
  - Reduced fertilizer and pesticide use, more efficient input manufacturing
  - Switch from gasoline to diesel
  - Higher yields
  - Reduced tillage

- Much yet to do
  - Organic conversion?
  - Re-integrate animal and plant production?
  - Solar greenhouses?
Is organic agriculture more energy efficient than conventional?

• Usually, not always
  50
  Frequency (%)

• Most difference due to N fertilizer

• Exceptions are informative
  – Heated greenhouses
  – Flame weeding

  – Input transport
  – Low yield
N makes most of the difference

Figure 1. Energy input of forage production systems

Organic production systems tend to use less energy

<table>
<thead>
<tr>
<th>Review conclusion</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>In most field trials and studies of operating farms, the increase in yield for conventional production does not offset the extra energy used</td>
<td>Stolze et al, 2000 (Review)</td>
</tr>
<tr>
<td>Organic typically uses 30-50% less energy in production than comparable conventional agriculture. It uses energy more efficiently but requires more labor.</td>
<td>Ziesemer, 2007, UN-FAO (Review)</td>
</tr>
<tr>
<td>Organic agriculture performs much better than conventional concerning energy efficiency (output/input)</td>
<td>Gomiero et al, 2008 (Review)</td>
</tr>
</tbody>
</table>
“Because of its reduced energy inputs, organic agriculture is the ideal production method for biofuels.

[…]

As the aim of biofuels is to reduce dependency on non-renewable energy sources and to mitigate environmental damage of fossil fuel emissions, organic production of biofuels furthers these goals in a way that conventional agriculture does not.”
Replacing Fossil Fuels on the Farm

- Fertilizers and pesticides (32%)
  - Legumes to replace synthetic nitrogen fixation
  - Reconnect crop and animal production
  - Integrated pest management
    - Diversity
    - Resistant varieties
    - Place-appropriate production systems
    - Biological control, botanicals

- Diesel (27%)
  - Biodiesel
  - Equipment sized for task
  - Machinery maintenance
  - Draft power; human power

- Electricity (21%)
  - Solar
  - Wind
  - Hydro
  - Biomass
Food energy in tomato

- Fresh field tomatoes: 88 Calories/serving
- Canned tomatoes: 177 Calories/serving
- Greenhouse tomatoes: 1099 Calories/serving
- Food energy in tomato: 15 Calories/serving

Embodied energy (Calories/serving)
High tunnels and row covers instead of heated greenhouses
March 24, 2009, Shelbyville, KY.

Ken Waters
Tomato season

Greenhouse
- Transplant production
- Growth
- Harvest

Field
- Transplant production
- Growth
- Harvest

Fall high tunnel
- Transplant production
- Growth
- Harvest

Spring high tunnel
- Transplant production
- Growth
- Harvest

Month: D J F M A M J J A S O N D
Mulching: Paper & hay instead of plastic
Cover Cropping

- Rye/vetch mix adds ~135 lb N/ac
- Slow release
- Organic matter
- Erosion control

WVU organic research project

<table>
<thead>
<tr>
<th>Year</th>
<th>Soil organic matter (%)</th>
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<tbody>
<tr>
<td>1998</td>
<td>4.5</td>
</tr>
<tr>
<td>2000</td>
<td>5</td>
</tr>
<tr>
<td>2002</td>
<td>5.5</td>
</tr>
<tr>
<td>2004</td>
<td>6</td>
</tr>
<tr>
<td>2006</td>
<td>6.5</td>
</tr>
</tbody>
</table>
Winter Wheat/Crimson Clover
90 lbs./A  10 lbs./A
Planted 10/3/07
Reduced Tillage
Reducing Energy Costs in Buildings

- Stop Air Leaks
- Insulate Adequately
- Turn Down Heat
- Use a Smaller Space
  - Block off unused areas; heat smaller areas.
- Seek Cost-Effective Heat Sources
  - Wood, used motor oil, passive solar
- Maintain Heating Systems
- Light Efficiently
  - Replace incandescent with CFL, LED
  - Turn off when not in use
Farm Equipment

• Motors
  – Tune, clean & lubricate pumps, fans, blowers, compressors
  – Irrigate with low pressure drip system on timer; fix leaks and clogs

• Machinery
  – Reduce trips across field
  – Reduce cultivation
    • Shallow or none

• Machinery (cont.)
  – Avoid excess horsepower
    • Use the smallest tractor that will do the job
    • Big tractors are only efficient for big jobs
  – Tune, clean & lube
  – Reduce pickup truck use
    • Combine trips to town
    • Use phone or internet if possible
Human Power
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Learn more:
EnergyFarms.net
Organic.KYSU.edu

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