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
Changing face of US agriculture

US farmland (10^7 ha)

US farm population (10^6)

Onion (t/ha)

Potato (t/ha)

Grain corn (t/ha)

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

Direct energy use (10^{17} J)

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

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

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

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

Non-food 85.6%

Food system 14.4%

Households 4.1%

Food service 1.7%

Wholesale & retail 2.2%

Agriculture 2.0%

Processing 2.8%

Packaging 0.9%

Transportation 0.6%
## 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.
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
- 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>
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<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

Nova Scotia Windmill, Declan McCullagh
Embodied energy (Calories/serving)

- Fresh field tomatoes: 88
- Canned tomatoes: 177
- Greenhouse tomatoes: 1099
- Food energy in tomato: 15
High tunnels and row covers instead of heated greenhouses
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**
Mulching: Paper & hay instead of plastic
Cover Cropping

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