Total Energy Consumed in US Farms in 2002
Total = 1.7 Quadrillion BTUs

- Fertilizers: 28%
- Diesel: 27%
- Electricity: 21%
- LP Gas: 5%
- Natural Gas: 4%
- Gasoline: 9%
- Pesticides: 6%

John Miranowski, Iowa State University
Total Energy Consumed on US Farms, 1965-2002

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

John Miranowski, Iowa State University
US Farms:
Declining energy intensity

Energy/Output
(index ratio, 1996=1)

1940 1960 1980 2000 2020
Farm proportion of US energy use, 1970-2002
# 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>
</tbody>
</table>
Agriculture: Small piece of energy pie

- ~20% of food system energy use
- ~2% of national energy use (industrialized)

Exceptions:

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

Less intensive:
- Organic
- Grain
- Small farms?
Meat & dairy accounts for most food GHG emissions in US

- Mostly production, not transport
- Mostly CH$_4$ and N$_2$O
- Mostly not energy related

Animal products account for half the energy in Swedish Agriculture.

- Grazing systems use much less energy than feed-based systems.

Wallgren & Höjer. 2009. 
Energy Policy 37: 5803–5813
Energy use accounts for most greenhouse gas emissions in most of the economy… not so for agriculture!
2006 Agriculture Chapter Greenhouse Gas Emission Sources

Agricultural Soil Management: 265.0 Tg CO₂ Eq.

Enteric Fermentation

Manure Management

Rice Cultivation

Field Burning of Agricultural Residues

Agriculture as a Portion of all Emissions: 6.4%
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

- Grazing only
- 1 cut + grazing
- 2 cuts + grazing
- 4 cuts

Organic production systems tend to use less energy

<table>
<thead>
<tr>
<th>Study conclusion</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 years of organic corn/soy/wheat in Pennsylvania used 30% less energy with no yield reduction</td>
<td>Pimentel et al. 2005</td>
</tr>
<tr>
<td>Conventional apricot production uses 38% more energy than organic in Turkey</td>
<td>Gündoğmuş 2006</td>
</tr>
<tr>
<td>Organic olive production in Spain is more energy efficient than conventional</td>
<td>Guzmán and Alonso 2008</td>
</tr>
<tr>
<td>12 years of organic wheat/pea/flax in Manitoba used 50% less energy but had only 30% lower yield</td>
<td>Hoeppner et al. 2006</td>
</tr>
<tr>
<td>Organic milk and rye production in Finland used 31 and 13% less energy, respectively</td>
<td>Grönroos 2006</td>
</tr>
</tbody>
</table>
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.”
Energy use for organic production in UK (% of conventional)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>71</td>
</tr>
<tr>
<td>Canola</td>
<td>75</td>
</tr>
<tr>
<td>Potatoes</td>
<td>102</td>
</tr>
<tr>
<td>Carrots</td>
<td>75</td>
</tr>
<tr>
<td>Cabbage</td>
<td>28</td>
</tr>
<tr>
<td>Onion</td>
<td>84</td>
</tr>
<tr>
<td>Leek</td>
<td>42</td>
</tr>
<tr>
<td>Beef</td>
<td>65</td>
</tr>
<tr>
<td>Sheep</td>
<td>80</td>
</tr>
<tr>
<td>Pork</td>
<td>87</td>
</tr>
<tr>
<td>Milk</td>
<td>62</td>
</tr>
<tr>
<td>Chicken</td>
<td>132</td>
</tr>
<tr>
<td>Eggs</td>
<td>114</td>
</tr>
<tr>
<td>Greenhouse tomatoes</td>
<td>130</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>85</td>
</tr>
</tbody>
</table>

Azeez 2007 from MAFF/Defra data
<table>
<thead>
<tr>
<th>Type of Tomatoes</th>
<th>Embodied Energy (Calories/serving)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh field tomatoes</td>
<td>88</td>
</tr>
<tr>
<td>Canned tomatoes</td>
<td>177</td>
</tr>
<tr>
<td>Greenhouse tomatoes</td>
<td>1099</td>
</tr>
<tr>
<td>Food energy in tomato</td>
<td>15</td>
</tr>
</tbody>
</table>
Canagro Greenhouses Inc.
Delta, BC

33 acres
12 acres
12 acres
33 acres
High tunnels and row covers instead of heated greenhouses
Tomato season

Greenhouse
Field
Fall high tunnel
Spring high tunnel

- Transplant production
- Growth
- Harvest
Chinese-style solar greenhouse

- Thermal blanket unrolled across outside surface of plastic to hold heat overnight.
- Insulated sloping roof lined with white roofing tin to reflect sunlight onto plants.
- Sand-filled wall insulated on north-facing side, stores heat during day, radiates heat overnight. Wall surface painted black to absorb and radiate more heat.

Performance on Coldest Night

ARGON
Max temp: 24.3°C
Min temp: -6.1°C

BUBBLE
Max temp: 21.4°C
Min temp: -9.7°C

NO INSULATION
Max temp: 20.3°C
Min temp: -13.3°C

OUTDOORS
Max temp: -26.4°C
Min temp: -41.4°C
Max solar radiation: 445.6 W/m²

Feb. 4  Feb. 5  Feb. 6  Feb. 7
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
Perennial-based systems

- More energy efficient
- Greater C sequestration
- Greater water and nutrient capture
  - Drought tolerant
  - Less pollution
- Build soil
  - Less disturbance
- Head start in spring

Wes Jackson, The Land Institute
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
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
Contact:
Michael Bomford
502-597-5752
Michael.Bomford@KYSU.edu

Learn more:
EnergyFarms.net
Organic.KYSU.edu

Thanks to
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• Kimberley Holmes
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• Tony Silvernail
• John Rodgers
• Joelle Johnson
• Brian Geier
• KSU Farm crew
• CASS program
• Post Carbon Institute

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