Farming with Less Fossil Fuel

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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…)
  - Reduce risk; enhance security, independence

- **Prepare for energy-constrained future**
US Energy Consumption by Source, 1775-2006

Exajoules

- Coal
- Natural gas
- Petroleum
- Nuclear
- Hydro
- Geothermal
- Solar
- Wind
- Biomass

1775 1825 1875 1925 1975
US Energy Consumption, 1950-2025

Energy consumption (EJ)

Real oil price (2005 $/barrel)
Oil and Commodity Crop Price Index, 2000-2009 (2000 price = 1)
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 in US Farms in 2002
Total = 1.7 Quadrillion BTUs

- **Fertilizers**: 28%
- **Diesel**: 27%
- **Electricity**: 21%
- **Natural Gas**: 4%
- **Gasoline**: 9%
- **LP Gas**: 5%
- **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
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
Emissions Allocated to Economic Sectors

Note: Does not include U.S. territories.
Emissions with Electricity Distributed to Economic Sectors

- Industrial
- Transportation
- Residential
- Commercial
- Agriculture

Note: Does not include U.S. territories.
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%
US Food System: 7.3 Calories Expended for Each Calorie of Food Energy

- Farming, 1.6 calories
- Transport, 1.0 calorie
- Processing, 1.2 calories
- Commercial food service, 0.5 calories
- Food retail, 0.3 calories
- Packaging, 0.5 calories
- Household storage and preparation, 2.3 calories

Heller and Keoleian, 2000, University of Michigan Center for Sustainable Systems
Food energy in tomato (Calories/serving):
- Fresh field tomatoes: 88
- Canned tomatoes: 177
- Greenhouse tomatoes: 1099
- Food energy in tomato: 15
Total greenhouse gas emissions per kg

Halberg 2008. International Centre for Research in Organic Food Systems
<table>
<thead>
<tr>
<th>Crop</th>
<th>Energy Use (% of conventional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>71</td>
</tr>
<tr>
<td>Canola</td>
<td>75</td>
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<tr>
<td>Potatoes</td>
<td>102</td>
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<tr>
<td>Carrots</td>
<td>75</td>
</tr>
<tr>
<td>Cabbage</td>
<td>28</td>
</tr>
<tr>
<td>Onion</td>
<td>84</td>
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<tr>
<td>Leek</td>
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<td>Beef</td>
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<td>Sheep</td>
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<td>Pork</td>
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<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>Average</td>
<td>85</td>
</tr>
</tbody>
</table>

Azeez 2007 from MAFF/Defra data
The “food mile” is a misleading concept:

*How* food travels has more impact on energy use and greenhouse gas emissions than how far it travels.

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Energy inputs for a 455 g can of sweet corn

Production: 450 kcal
Processing: 316 kcal
Packaging: 1006 kcal
Transportation: 158 kcal
Distribution: 340 kcal
Shopping: 311 kcal
Home prep.: 457 kcal
Total: 3065 kcal

Food energy in corn: 375 kcal
Western Lettuce Now Inc., Langley BC

6 acres

8 acres
High tunnels and row covers instead of heated greenhouses
Greenhouse: 2129 MJ/m²/yr

- 341 MJ/m²/yr for electricity
- 1750 MJ/m²/yr for natural gas

Materials:
- Steel
- Plastic
- Aluminum
- Wood
- Glass
- Concrete
Greenhouse: 2129 MJ/m²/yr
High tunnel: 95 MJ/m²/yr
Yield per 100 m²

- Greenhouse
- High Tunnel

Lettuce or Tomato

Heads (lettuce) or kg (tomato) per 100 m²

- Lettuce
  - Greenhouse: 7000
  - High Tunnel: 2000

- Tomato
  - Greenhouse: 3000
  - High Tunnel: 500
Energy extracted from a large head of lettuce by human digestion: 0.3 MJ (76 Kcal)
Tomato season

- Greenhouse: Winter
- Field: Spring
- Fall high tunnel: Summer
- Spring high tunnel: Fall

- N: November
- D: December
- J: January
- F: February
- M: March
- A: April
- M: May
- J: June
- J: July
- A: August
- S: September
- O: October
- N: November
- D: December

- Orange: Transplant production
- Green: Growth
- Red: Harvest
Mulching: Paper & hay instead of plastic
Cover Cropping

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

WVU organic research project

- Winter rye & vetch cover crop
- Cover crop + compost @10t/ac

Soil organic matter (%)
Winter Wheat/Crimson Clover

90 lbs./A  10lbs./A

Planted 10/3/07
Reduced Tillage
Compost
“Because of its reduced energy inputs, organic agriculture is the ideal production method for biofuels.

[...] Organic agriculture offers a favourable energy balance because of its lower energy requirements.

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.”
Edamame soybean yields

- Most energy efficient
- Most efficient use of land
- Most labor efficient

Biointensive Market Garden Small Farm

kg/m², kg/min

kg/MJ

kg/m²

kg/min

kg/MJ

0

0.2

0.4

0.6

0.8

1

0

0.2

0.4

0.6

0.8

1

Biointensive Market Garden Small Farm

Kentucky State University
Energy Smart Food Choices

- Less meat and seafood
  - Choose poultry and grass-fed animals
- More fruit and vegetables, in season
  - Avoid greenhouse-grown produce
- More local and organic foods
  - Avoid foods flown in
  - Avoid frequent car trips to grocery store
- Whole foods, not processed
- Less refrigeration
- More microwave and stove top; less baking
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Organic.KYSU.edu

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