Energy and Organic Agriculture

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Community Research Service
Organic goal: Sustainable use of renewable resources

• Ideal, not requirement. Are we close?

• Requires replacement of fossil fuels with renewable fuels

– Biofuels
  • Biomass heat
  • Draft power
  • Bioethanol
  • Biodiesel
  • Biogas
  • Syngas

– Wind
– Solar
– Hydro
– Geo-thermal

Nova Scotia Windmill, Declan McCullagh
Albert Howard (1873-1947)

- British agricultural scientist.
- 25 years in India.
- Critical of reductionist agricultural science and specialization
- Blamed fall of past civilizations on unsustainable agriculture
- Wrote *An Agricultural Testament* (1940)
Howard on Eastern agriculture

“The small-holdings of China, for example, are still maintaining a steady output and there is no loss of fertility after forty centuries of management.”

• Tiny farms
• Labor intensive
• Integration of crops and livestock
• Lots of legumes
• Little cultivation
Howard on Western agriculture

- Large, growing farms
- Monocultures
- Mechanization
  - Machines consume resources but do not contribute urine/dung
- Synthetic fertilizer dominates
- Food prices too low... farmers forced off land
Winter Wheat/Hairy Vetch

90 lbs./A  10 lbs./A

Planted 10/3/07
_Agriculture as a Producer and Consumer of Energy_
US Energy Consumption, 1950-2025

Energy consumption (EJ)

Real oil price (2005 $/barrel)
Total Energy Consumed in US Farms in 2002
Total = 1.7 Quadrillion BTUs

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

John Miranowski, Iowa State University
North American Ag Energy Use

- Production of 1 kg of N requires 51-68 MJ (about 1.5 l of diesel fuel).
- Manure-based corn production uses 31-34% of the energy of inorganic fertilizer based production.

B.A. Stout, 1984
Energy Use and Management in Agriculture

McLaughlin et al, 2000, Canadian Agricultural Engineering 42:1
Total Energy Consumed on US Farms, 1965-2002

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

John Miranowski, Iowa State University
Figure 3. Average energy use per hectare in the organic and conventional dairy farm sector of Denmark, 1999
Figure 1. Energy input of forage production systems

Total greenhouse gas emissions per kg

- Conventional
- Organic

- Pork
- Semifat milk
- Potatoes
- Carrots
- Greenhouse tomatoes
- Wheat
- Oat
- Rapeseed

Halberg 2008. International Centre for Research in Organic Food Systems
Organic production systems tend to use less energy

<table>
<thead>
<tr>
<th>Study conclusion</th>
<th>Reference</th>
</tr>
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<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>
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Organic production systems tend to use less energy

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<td>12 years of organic wheat/pea/flax in Manitoba used 50% less energy but had</td>
<td>Hoeppner et al. 2006</td>
</tr>
<tr>
<td>30% lower yield</td>
<td></td>
</tr>
<tr>
<td>Organic milk and rye production in Finland used 31 and 13% less energy, respectively</td>
<td>Grönroos 2006</td>
</tr>
<tr>
<td>In most field trials and studies of operating farms, the increase in yield for</td>
<td>Stolze et al, 2000</td>
</tr>
<tr>
<td>conventional production does not offset the extra energy used</td>
<td></td>
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</table>
Energy use for organic production in UK (% of conventional)

<table>
<thead>
<tr>
<th>Food</th>
<th>% of conventional</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>
</tbody>
</table>

Average: 85

Azeez 2007 from MAFF/Defra data
US Food System: ~10 EJ/yr

Data from Heller and Keoleian, 2000; Graph from www.ethicurian.com

- Agricultural production, 21.5%
- Household storage and preparation, 31.7%
- Transportation, 13.6%
- Commercial food service, 6.6%
- Processing, 16.4%
- Packaging, 6.6%
- Food retail, 3.7%

Hatching: refrigeration

Food Energy Available: ~1 EJ/yr
Full cost accounting*
Social cost of wheat in UK

*Includes costs of production, water and air pollution, soil erosion and quality, biodiversity loss, health impacts, traffic congestion, accidents, infrastructure & noise.
### Organic Agriculture Saves Energy

...but the saving can be eaten up by hauling

<table>
<thead>
<tr>
<th>Crop</th>
<th>Organic energy saving (MJ/kg)</th>
<th>Freight distance (miles) equivalent to saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter wheat</td>
<td>0.9</td>
<td>486</td>
</tr>
<tr>
<td>Cabbage</td>
<td>0.6</td>
<td>324</td>
</tr>
<tr>
<td>Leek</td>
<td>0.5</td>
<td>270</td>
</tr>
<tr>
<td>Onion / potato</td>
<td>0.4</td>
<td>216</td>
</tr>
</tbody>
</table>

**Note:**
- Air freight distances are not provided in the table.
Distance traveled (left) vs. greenhouse gas emissions (right)

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.

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 preparation: 457 kcal

Total energy: 3065 kcal

Food energy in corn: 375 kcal
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
“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.”
Oil and food commodity prices, 2000-2008

Crude oil ($/barrel)

Wheat ($/bushel)

Corn ($/bushel)

Soybean ($/bushel)

http://futures.tradingcharts.com/

www.rodaleinstitute.org/Organic-Price-Report
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

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