Energy Usage in Regional Food Production

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Energy Use in the Food System

Heller and Keoleian, Report No. CSS00-04 of the Center for Sustainable Systems, School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI
Transportation:
distance and mode from producer to consumer

Top three points of origin

- 28% from Ca and AZ
- 16% from Florida
- 24% from outside US

*Calculations by N. Bamberger and J. Archer, summer High School interns (U of Chicago, 2009); Based on food movement data, AMS USDA*
Consumption pattern:
Per Capita Mean American Diet

- Fr+Veg: 360 kcal/day, 2318 kg/yr, 0.15 Fractional energy use
- Grain for food: 310 kcal/day, 321 kg/yr, 0.35 Fractional energy use
- Animal/Feed: 1045 kcal/day, 428 kg/yr, 0.50 Fractional energy use

Calculated from USDA and FAOSTAT data; Energy after Matthew and Weber 2008
The goal: Evaluate efficiency and potential of a regional food system

The Tools:
Whole farm analysis
Foodshed mapping
Life cycle system analysis
Previous work has focused on single crops

TABLE 11.1
Energy Inputs in Apple Production in the Eastern United States

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Quantity/ha</th>
<th>kcal/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>385 h</td>
<td>17,150,000</td>
</tr>
<tr>
<td>Machinery</td>
<td>88 kg</td>
<td>1,408,000</td>
</tr>
<tr>
<td>Diesel</td>
<td>483 L</td>
<td>5,506,000</td>
</tr>
<tr>
<td>Gasoline</td>
<td>1346 L</td>
<td>13,406,000</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>45 kg</td>
<td>837,000</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>114 kg</td>
<td>472,000</td>
</tr>
<tr>
<td>Potassium</td>
<td>114 kg</td>
<td>372,000</td>
</tr>
<tr>
<td>Insecticides</td>
<td>47 kg</td>
<td>4,700,000</td>
</tr>
<tr>
<td>Herbicides</td>
<td>6 kg</td>
<td>600,000</td>
</tr>
<tr>
<td>Fungicides</td>
<td>49 kg</td>
<td>4,900,000</td>
</tr>
<tr>
<td>Electricity</td>
<td>66 kWh</td>
<td>57,000</td>
</tr>
<tr>
<td>Transportation</td>
<td>2974 kg</td>
<td>787,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>50,195,000</td>
</tr>
</tbody>
</table>

Pimentel and Pimental, 1996;2007
Local yields, small farms

- 4 rural farms, 2-20 acres
- 4 urban farms
- Highly diversified in produce (40-300 varieties)
- “Sustainable” practices
Our approach: Whole Farm study
Full “input/output” analysis for energy

INPUTS:
(1) “Direct” on-farm energy use
(2) “Indirect” energy: material inputs
(3) Labor

OUTPUTS:
Itemized production
Output analysis: Calculating yields from diversified, sustainable farms

Equivalent land use \( = \sum_{i=1}^{N} \frac{\text{Mass of item } i, \text{ kg yr}^{-1}}{\text{Conventional Yield, kg acre}^{-1} \text{ yr}^{-1}} \)

Relative land use \( = \frac{\text{Equivalent land use}}{\text{Actual production area}} \)

Relative Land Use > 1, diverse farms use more land
Relative Land Use < 1, diverse farms use less land
Input – Output analysis: Preliminary results 
small, diversified vs conventional ag

• **Urban Farms:**
  • Land use: 0.5 to 1 acre per acre of conventional
  • Direct energy use: 5 – 15% of conventional
  • Indirect energy use: 25 – 50% of conventional

• **Rural Farms:**
  • Land use: 1.1 -1.8 acre per acre of conventional
  • Direct energy use: 30 – 95% of conventional
  • Indirect energy use: 25 – 70% of conventional
Energy Use in the Food System

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Per Capita Mean American Diet

- **kcal/day**: 3753
  - Fr+Veg: 360 kcal/day
  - Grain for food: 2318 kcal/day
  - Animal/Feed: 1045 kcal/day

- **kg/yr**: 1059
  - Fr+Veg: 310 kg/yr
  - Grain for food: 321 kg/yr
  - Animal/Feed: 428 kg/yr

- **acres/yr**: 0.86
  - Fr+Veg: 0.03 acres/yr
  - Grain for food: 0.16 acres/yr
  - Animal/Feed: 0.67 acres/yr

Calculated from USDA and FAOSTAT data; Land from Martin et al and Eshel et al. 2010
Foodsheds, small to large

- Chicago Foodshed
- Urban centers, *US Census*
- Prime farmland, *USDA/SSURGO*
- Secondary foodsheds
Upper Mississippi Foodsheds

- Urban centers, *US Census*
- Foodsheds
- Prime farmland, *USDA/SSURGO*
Transportation: Distance and Load

Top three points of origin

- 28% from Ca and AZ
- 16% from Florida

- Calculations by N. Bamberger and J. Archer, summer High School interns (U of Chicago, 2009); Based on food movement data, AMS USDA
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Farmers’ Market Survey Data

Less than 2 miles
80% walk or bike
Distribution: Fresh from the farm

- Farmers’ Markets
- Community Gardens
Cultivated Land surrounding Chicago

- **Urban centers, US Census**
  
  *Chicago = 8.3E6*

- **42.5E6 acres**

  *USDA/SSURGO*
Increasing the data collection (2011)

(1) Adding nine farms in three regions of the US

(2) Adding self reporting farms in midwest

(3) Monitoring water use on two farms

(4) Additional economic data
Challenge: Comparing “apples to apples”

(1) Categories of inputs
(2) “Stages” of the Life Cycle
  - production/post harvest
  - marketing
  - delivery
  - waste

TABLE 11.1
Energy Inputs in Apples

Inputs
Labor
Machinery
Diesel
Gasoline
Nitrogen
Phosphorus
Potassium
Insecticides
Herbicides
Fungicides
Electricity
Transportation
Total
Energy Use in the Food System

Richard Schneider, formerly of Sysco, Ag Forum 2010 speaker
Acknowledgments

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New partners in 2010:
Bon Appétit Management Foundation
Farm to School
Greenhouse gas emissions associated with the US food system

- Energy use in the food system
- Agriculture land management
- Enteric fermentation
- Manure management
- Rice cultivation + field burning

- Energy use from USDA, 2010; Emissions data from EPA, 2009; import/export, FAO 2008
Land requirements for US diet

\[ \text{Acres for fruit + veg} = \frac{\text{Accres for food grain}}{\text{US Population}} = \frac{\text{Acres for feed grain}}{\text{US Population}} \]

- **corn**: 33,365
- **hay**: 62,241
- **soybean**: 23,461
- **wheat**: 16,128
- **sorghum**: 1,488
- **barley**: 1,173
- **oats**: 2,222
- **total**: 140,077

Data from USDA food availability, USDA grain yearbook, and FAOSTAT
Population and land resources

- **Urban centers**, *US Census*
- **Prime farmland**, *USDA/SSURGO*
Ultimate destination of farm fresh produce