Controlled Environment Agriculture: a Technological Suite of Opportunities and Constraints

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Outline

• Crucial factors
• Economic viability
• Intersection of food and energy
• Operational issues
• Upcoming technological innovations
• Labor and leadership
Crucial Factors for Controlled Environment Agriculture

Objective Functions
- Revenues per square meter
- EBITDA per square meter
- Kilograms per square meter
# Economic Viability of Controlled Environment Agriculture

<table>
<thead>
<tr>
<th></th>
<th>Berlin, NH</th>
<th>$\frac{1}{2}$ Revenues, Labor Cost</th>
<th>$\frac{1}{4}$ Revenues, Labor Cost, Energy Cost</th>
<th>$\frac{1}{10}$ Revenues, Labor Cost, Energy Cost</th>
<th>$\frac{1}{2}$ Revenues, Labor Cost, Energy Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue ($MM)</td>
<td>27.0</td>
<td>13.5</td>
<td>6.7</td>
<td>6.7</td>
<td>13.5</td>
</tr>
<tr>
<td>Labor Cost ($MM)</td>
<td>6.4</td>
<td>3.2</td>
<td>1.6</td>
<td>0.6</td>
<td>0.6</td>
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<tr>
<td>Energy Cost ($MM)</td>
<td>2.1</td>
<td>2.1</td>
<td>0.5</td>
<td>1.2</td>
<td>1.2</td>
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<tr>
<td>Agricultural Inputs Cost ($MM)</td>
<td>6.9</td>
<td>6.9</td>
<td>6.9</td>
<td>6.9</td>
<td>6.9</td>
</tr>
<tr>
<td>EBITDA ($MM)</td>
<td>11.7</td>
<td>1.4</td>
<td>-2.2</td>
<td>-1.9</td>
<td>4.8</td>
</tr>
</tbody>
</table>
Intersection of Food and Energy

• Role of Combined Heat and Power (CHP)
  • Energy sustainability
  • CO₂ sequestration
• Photon flux density versus BTU requirements
Operational Issues with State-of-the-Art Greenhouses

Importance of location:

- Light
- Temperature
- Proximity to market
- Site characteristics
  - Terrain
  - Wetlands
  - Geology
Operational Issues with State-of-the-Art Greenhouses (cont.)

• Labor availability
• Fuel availability
• Disease
• Insects
• Climate control
• Packaging
Upcoming Technological Innovations

• Photoperiod manipulation
• Disease and insect resistance
• Taste improvement
• Color improvement
• Adjusting ecological responses
Upcoming Technological Innovations (cont.)

- Multiplying fruiting period
- Adjusting germination rates
- Creation of organic feedstocks
- Automated harvesting
Labor and Leadership

• Proper compensation of all workers
• Appropriate benefit strategies (i.e. vacations, insurance, child care)
• Commitment through ownership
• Success oriented compensation
Labor and Leadership (cont.)

• Education and training of all workers
  • Community ecology
  • Safety
  • Personal health

• Requirements for successful general manager
  • Minimum 15 years of experience in greenhouse operations
  • Prior profit/loss responsibility