Techno-economic analysis

Eco-Feed
Tomato side streams
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Presentation overview

Practical question:
How to come to a promising business?

Cases:

1. Low-tech for low value: mixed food waste to animal feed
2. Medium-tech for moderate value: tomato paste
3. High-tech for high value: tomato extracts
Techno-economic analysis

- Specify the intended processing chain: unit operations
- Choose appropriate equipment types
- Choose appropriate dimensioning for intended practical scale
- Derive cost estimates for equipment
- Correct for annual price variations
- Estimate other capital costs
- Estimate variable costs (labour, energy, etc.)
- Estimate scale size dependencies
Techno-economic evaluation

Case definition
- Raw material composition
- Product specifications
- Annual production

Process design
- Unit operations
- Equipment sizes
- Flow sizes

Purchased equipment cost

Fixed capital
- Inside battery limits costs
- Outside battery limits costs
- Design and engineering
- Contingency

Material related costs
- Raw materials
- Utilities
- Consumables

Labour related costs
- Operating labour
- Supervision
- Overhead

Plant related costs
- Maintenance
- Plant overhead
- Taxes and insurance

Financing cost
- Interest
- Life

OPEX

CAPEX

Production costs
“Eco-Feed”

- Feed-grade former food waste handling
- Refrigerated collection transport
- Processing:
  - hygienic processing
  - milling/homogenisation
- Safe storage
- Distribution transport
Typical result

Costs and benefits (for reference scale size: 26 kton food waste per year and typical transport distances)

- Feed transport: 16 euros
- Processing: 38 euros
- FW transport: 11 euros
- FW collection: 12 euros
- Prevented disposal Costs: -40 euros
- Value liquid feed: -58 euros
Effects of scale size on individual cost

- Processing costs
- Collection costs
- Slurry feed distribution costs
- Selling price slurry feed
- Prevented costs waste disposal
- Net costs

Annual food surpluses processing in one factory (kton/year)

Costs (euro per tonne food surplus)
Optimisation

![Graph showing costs vs. capacity for FW transport, processing, and FW transport + processing. Costs are expressed in €/ton food waste, and capacity is in kton FW/y. The graph indicates cost savings as capacity increases.]
Different geographic scenarios

Costs (euro per tonne food surplus)
Conclusions valorisation for feed

- Relatively low-tech
- Strong trade-offs between logistic costs and processing economies of scale
- Most promising in areas with sufficient supply + local market
- May fail at too small scale!
Medium-tech: Tomato paste

Food waste valorisation:
- Small scale factory, using reject and surplus tomato (150ha greenhouse)
- Medium scale: from 1500ha greenhouses

Reference:
- Large scale factory, using tomato specifically produced for this purpose
Typical factory layout

(Angeles-Martinez et al., 2018)
### Tomato paste results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Small scale</th>
<th>Medium scale</th>
<th>Large scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant capacity (kton tomato/y)</td>
<td>3.0</td>
<td>30</td>
<td>300</td>
</tr>
<tr>
<td>Production (kton paste/y)</td>
<td>0.56</td>
<td>5.6</td>
<td>56</td>
</tr>
<tr>
<td>Processing (h/d)</td>
<td>8</td>
<td>16</td>
<td>24</td>
</tr>
<tr>
<td>Operating hours (h/y)</td>
<td>2667</td>
<td>5333</td>
<td>8000</td>
</tr>
<tr>
<td>Shift positions (#)</td>
<td>0.33</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Transport distance (km)</td>
<td>20</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Purchased equipment costs (k€)</td>
<td>391</td>
<td>975</td>
<td>2922</td>
</tr>
<tr>
<td>Fixed capital (k€)</td>
<td>2055</td>
<td>5117</td>
<td>15302</td>
</tr>
<tr>
<td>Financing</td>
<td>206</td>
<td>512</td>
<td>1530</td>
</tr>
<tr>
<td>Plant related</td>
<td>206</td>
<td>512</td>
<td>1530</td>
</tr>
<tr>
<td>Labour related</td>
<td>149</td>
<td>891</td>
<td>1337</td>
</tr>
<tr>
<td>Cans &amp; boxes</td>
<td>171</td>
<td>1715</td>
<td>17149</td>
</tr>
<tr>
<td>Thermal energy</td>
<td>16</td>
<td>160</td>
<td>1601</td>
</tr>
<tr>
<td>Electricity</td>
<td>5</td>
<td>53</td>
<td>531</td>
</tr>
<tr>
<td>Transport</td>
<td>96</td>
<td>4800</td>
<td></td>
</tr>
<tr>
<td>Tomato (raw mat.)</td>
<td>22500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (€/y)</td>
<td>752</td>
<td>3939</td>
<td>50978</td>
</tr>
</tbody>
</table>

**Competitive if:**
- sufficient scale size
- continuity over the year
High-tech: Oil Extraction & Carotenoids Extraction from seeds+peels

"European scale" factory

<table>
<thead>
<tr>
<th>Operating hours</th>
<th>8000 h/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drying &amp; Sieving</td>
<td>Oil Extraction</td>
</tr>
<tr>
<td>Input: Pulp</td>
<td>Seeds</td>
</tr>
<tr>
<td>26%</td>
<td>10.8</td>
</tr>
<tr>
<td>86.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Output: Seeds</td>
<td>Crude Oil</td>
</tr>
<tr>
<td>90%</td>
<td>8.9</td>
</tr>
<tr>
<td>86.6</td>
<td>1.1</td>
</tr>
</tbody>
</table>

- Seeds 90% - Crude Oil 100% - Carotenoids 90% DW
- Dried Peels 90% - Residue 100% DW

Price assumptions:
oil €3/kg
Carotenoids €1000/kg
Scale size analysis

Big factory scale!
Investments > M€10
Concluding remarks

- High added value valorisation:
  - high-tech, capital intensive processes
  - most beneficial at large scale
  - located near waste generation plant

- Low-tech valorisation:
  - lower capital requirements
  - logistic costs are relatively high
  -> location near waste concentration + end-users

- All solutions require sufficient scale size
- Not competitive at too small scale size

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Thank you!
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