Tørketeknologi og logistikk for marint råstoff

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Why drying?
Drying methods

Theoretically, a lot of different drying equipment may be used for dehydration of seaweed. Based on the task of utilising surplus heat and/or steam, indirect dryers and steam dryers will be most suited for further discussion.

**Hot air dryers**
- Conveyor (belt) dryers.
- Bin and cabinet dryers.
- Tunnel dryers.
- A rotary dryer.
- A fluidised bed dryer.

**Contact dryers**
- Drum dryers.
- The rotary disc dryer.
- The indirect tube dryer.
Summary

To optimise the drying system, the following bullet points are important:

• Air quantity, heating temperature, materials staying time and feeding speed must be adjusted to achieve the best drying effect.

• The equipment configuration must be flexible, and washing system and materials cooling system can be used.

• Energy efficiency, and air recycling to realize saving energy

• Air distribution systems make the hot air distribute uniform through the products, and increase and maintain constant quality of products.

• In addition to surplus heat as energy source, backup systems with steam, conduction oil, electricity or oil can be implemented.
Clipfish drying
Sorption isotherms for brown seaweed at 5, resp. 25, 40 and 55°C
This indicates bacteriological stability ($a_w < 0.9$) at 5°C below 0.40 moisture, dry basis. Initial moisture is about 4, dry basis, initial processing should remove 3.60 parts of moisture per part dry matter. This corresponds to a residual weight 28 percent of the initial, or 72 percent weight loss.
Energy required for moisture removal

In a convective dryer, about 100 kg of air must be circulated per kg of moisture removed.

In a simple, adiabatic air circulated dryer, at conditions relevant to this project, 1 kg of moisture removal corresponds to about 5000 kJ of energy supplied to the air.
# Sources of energy at the Waste to Energy plant

<table>
<thead>
<tr>
<th>#</th>
<th>Medium</th>
<th>Temp. C</th>
<th>Pressure, bar</th>
<th>Flow, t/h</th>
<th>Max. Output MW</th>
<th>Moisture removal kg/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HP Superheated Steam, turbine mainline</td>
<td>400</td>
<td>40</td>
<td>29</td>
<td>22</td>
<td>4,5</td>
</tr>
<tr>
<td>2</td>
<td>LP Saturated Steam from deaerator</td>
<td>120-160</td>
<td>2-3</td>
<td></td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Hot water, district heat line</td>
<td>85-100</td>
<td>2</td>
<td></td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Salt Water from scrubber cooling and moisture condensing</td>
<td>50</td>
<td>1</td>
<td>4,1</td>
<td>4,5</td>
<td>0,9</td>
</tr>
<tr>
<td>5</td>
<td>Air heating from flue gas cooling</td>
<td>300</td>
<td>1</td>
<td>15</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

In a short term, # 3, hot water from the district heating line, is the most likely to use in the harvesting season, i.e. the summer. Other sources, may be utilized when needed, especially for secondary processing on an all year basis. # 4 and # 5 will be energy recovered.
Primary processing capacity

• 1000 kg of seaweed requires removal of 720 kg moisture, corresponding to 3600000 kJ or 1000 kWh, or 1 MWh. Hence 1 MW corresponds to 1 t/h of seaweed primary processing.

• 50% of the district heating capacity in the harvesting season 10 MW, corresponds to primary processing of resp. 10 t/h 240 t/d or 7200 t/mth.

Secondary processing capacity

Assuming a finished product with less than 10 % moisture content, requires removal of 40 minus 11 percent moisture, dry basis. To dry the initial 1000 kg of seaweed into a finished product, further 60 kg of moisture must be removed, corresponding to 300000 kJ, or 83,3 kWh. Hence, the energy required for the secondary processing is significantly less then for the primary processing.
The harvesting season coincides with the low season for heating in Ålesund. Therefore, energy is available for primary processing of seaweed. One may assume that 50 percent, or 10 MW, is available in that season.
PROMAC WP 6

System Life Cycle Analysis and Value Chain Modelling
PROMAC WP 6 - Tasks

- Select system(s) for environmental Life Cycle Analysis (LCA), with definition of
  - Pilot products, production processes, functional units, impact categories related to nutrition and health
  - Value chains with related logistics solutions and business models
PROMAC VALUE CHAIN

Governance actors
Seaweed selection + Other factors

Product Process Transfer
Cultivation/Production → Harvesting → Processing phase 1 (Drying) → Processing phase 2 (Refining) → Distribution

Laboratories/Plant/Equipment
Technology/Computer systems
Logistics/warehousing
Marketing

Energy

Food safety authority
R & D institutions

End user
Human nutrition/food
- Omega 3, 6 & DHA oils
- Salad
- Protein additives

Animal feed
- Livestock feed
- Protein additives

Refined & other products
- Pharmaceutical products
- Biofuel
- Organic fertilizer

Support actors

Human nutrition/food
- Omega 3, 6 & DHA oils
- Salad
- Protein additives

Animal feed
- Livestock feed
- Protein additives

Refined & other products
- Pharmaceutical products
- Biofuel
- Organic fertilizer
Production in five Norwegian reference facilities

5 facilities of 25 ha
150 tons/ha/year

1. Yearly production
=> 20,000 tons w.w.

2. Dry material
=> 2-3,000 tons d.w.

3. Protein powder
=> 2-300 tons

Replacement of 25% of soyaprotein for Norwegian salmon feed (2012)

Requires 2000 facilities!

3. Yearly production
=> 7 million tons w.w.

2. Dry seaweed
=> 1 million tons d.w.

Norwegian salmon feed 1.6 m.t.
Protein powder 400,000 tons

1. ¼ protein powder from seaweed
=> 100,000 t.
Incurred Cost  Value creation

Value capture

* What the market is willing to pay for (Porter)