Tørketeknologi og logistikk for marint råstoff

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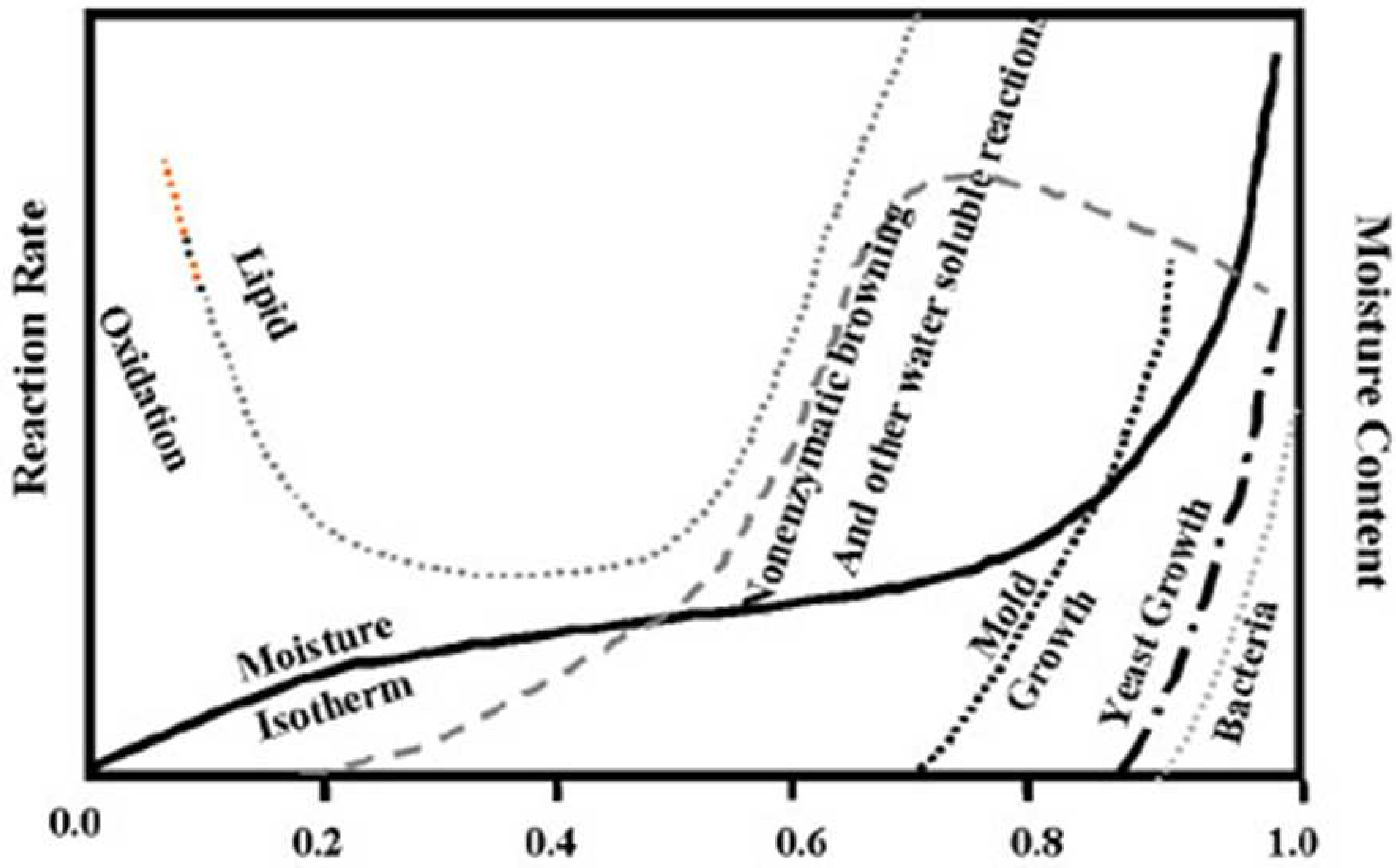
Why drying ?



Reaction Rate
Moisture Content
Lipid
Oxidation
Nonenzymatic browning
And other water soluble reactions
Moisture
Isotherm
Mold
Growth
Yeast Growth
Bacteria
0.0
0.2
0.4
0.6
0.8
1.0

Drying metodes

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 driers

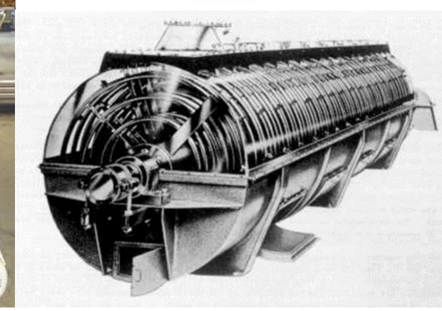
- Conveyor (belt) dryers.
- Bin and cabinet dryers
- Tunnel driers.
- A rotary dryer
- A fluidised bed dryer

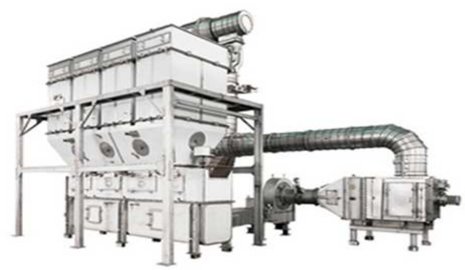
Contact driers

- Drum dryers
- The rotary disc dryer
- The indirect tube dryer





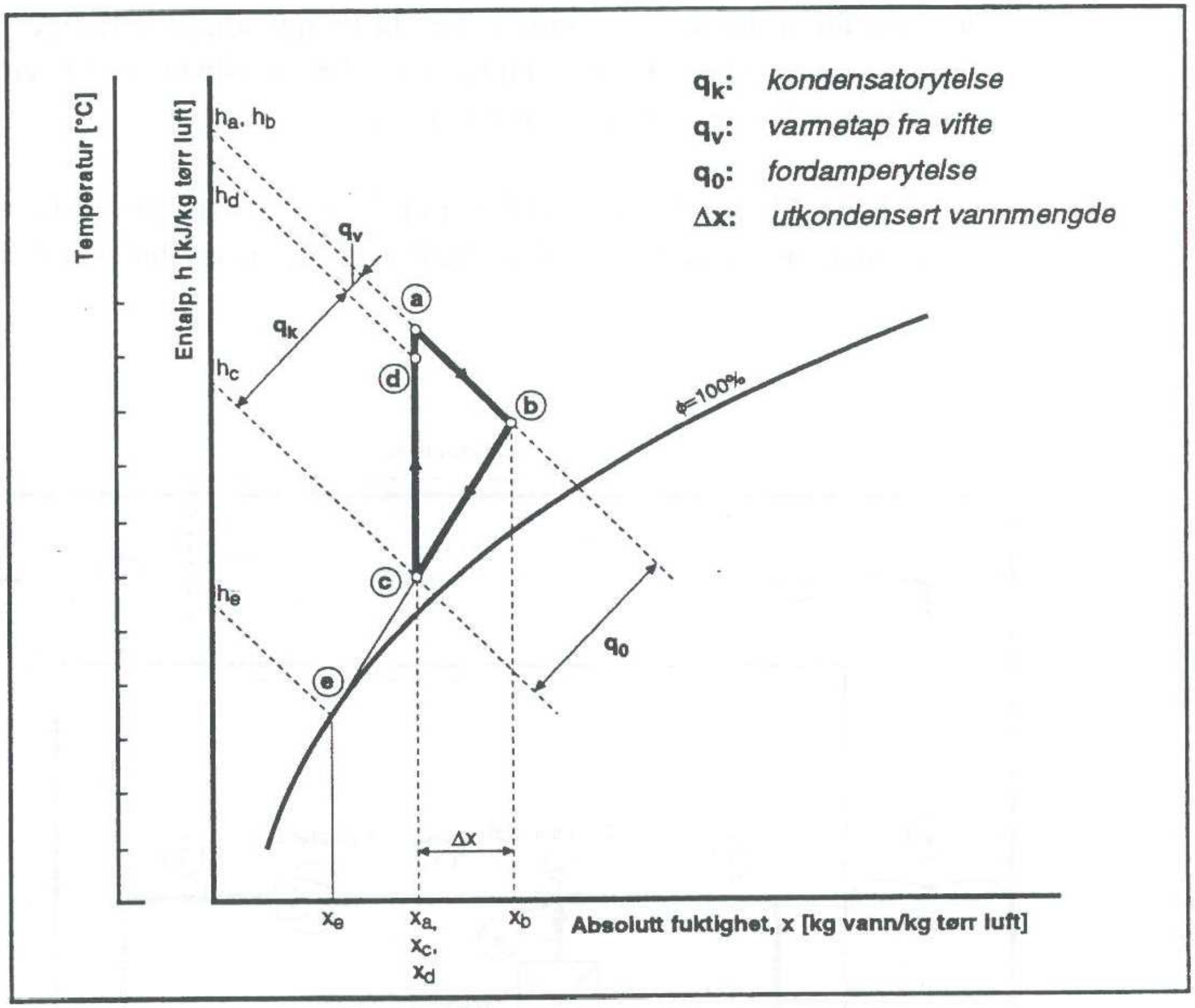


Summary

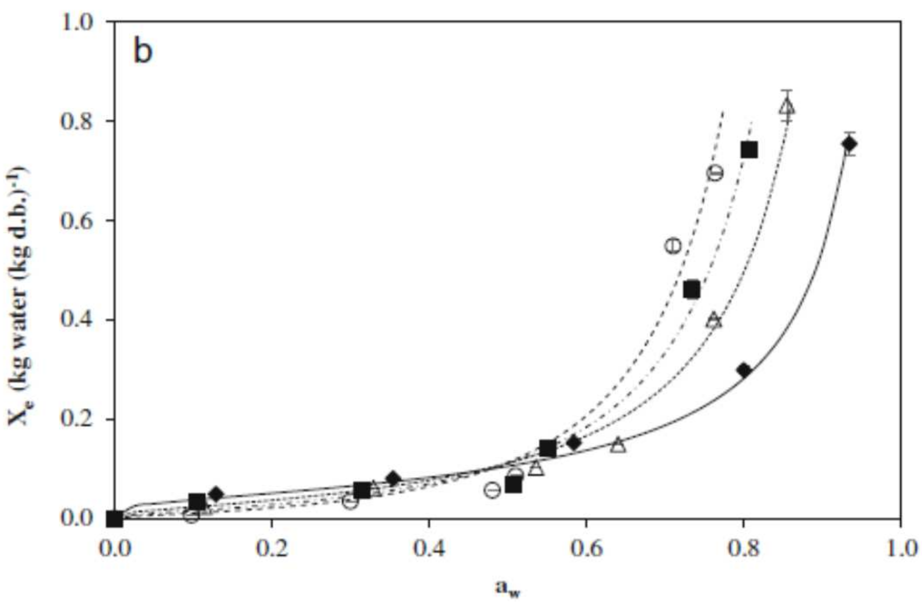
To optimise the drying system, the following bullet points are important:

- 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



Primary processing into bacterial stability



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.

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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

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

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.

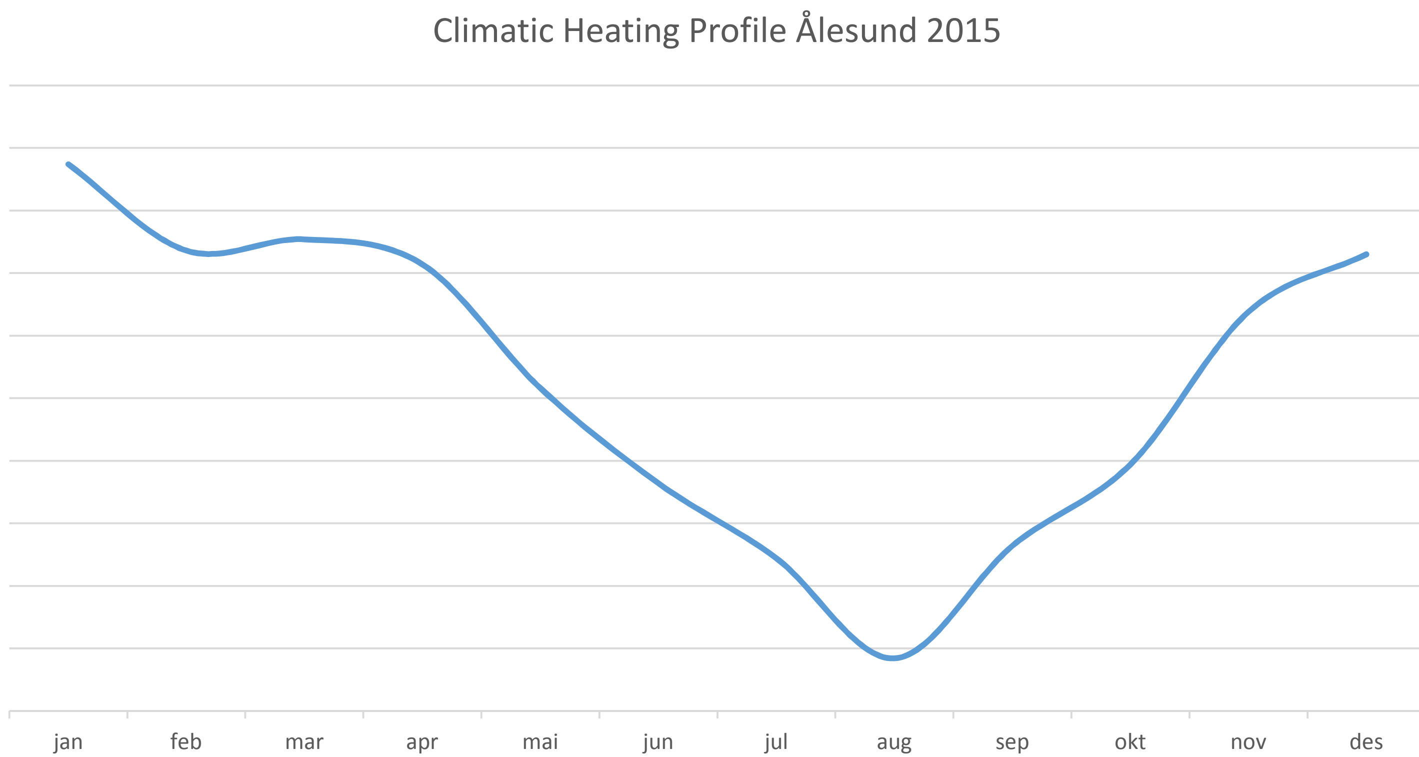
Primary processing capacity

- 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.

Available energy in the district heating system



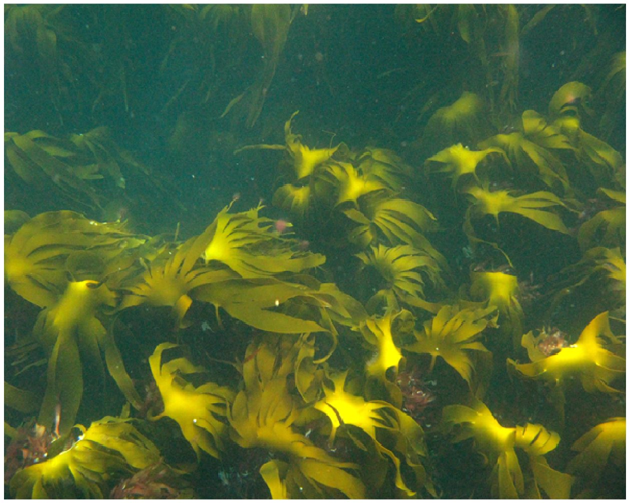
The harvesting season coincides with the low season for heating in Ålesund. Therefore, energy is available for primary processing of seaweed. One may assume that 50 percent, or 10 MW, is available in that season.

PROMAC WP 6

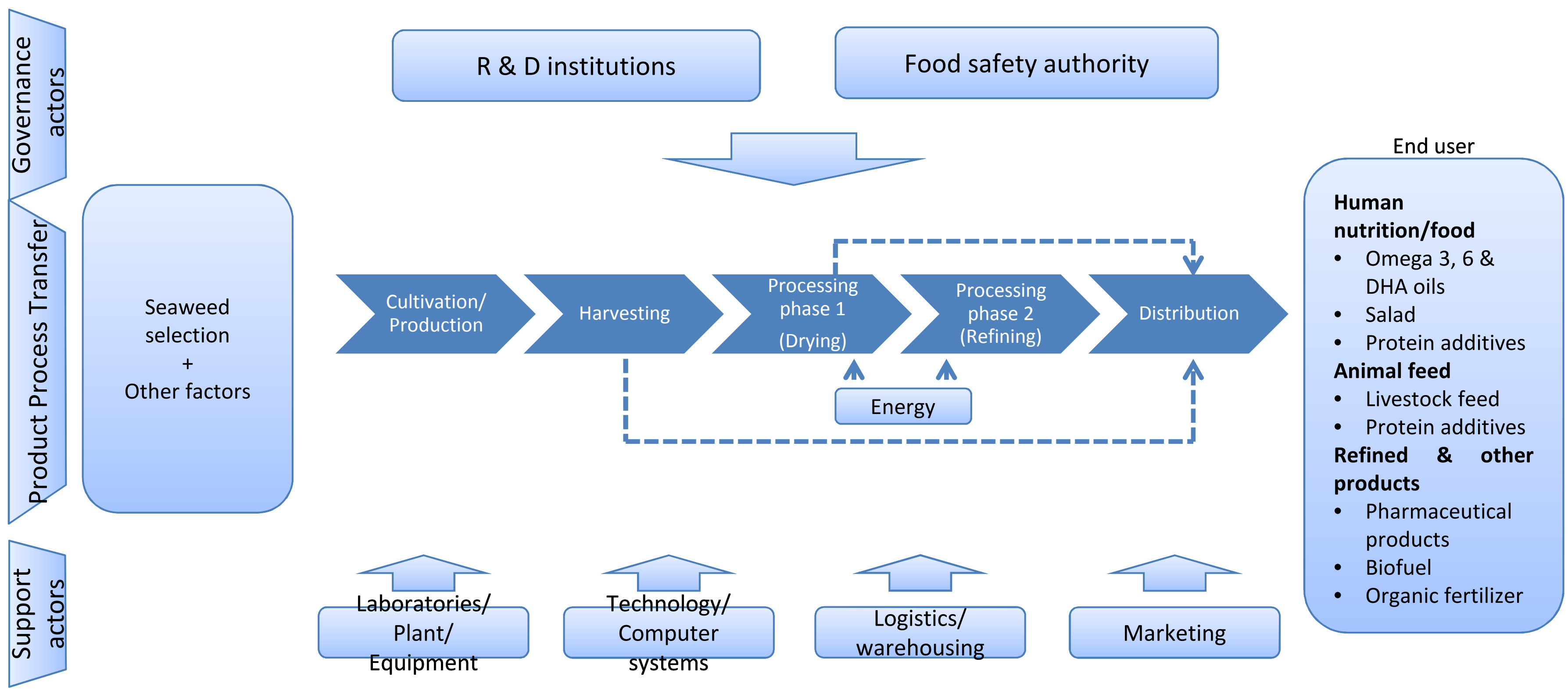
System Life Cycle Analysis and
Value Chain Modelling

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



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PROMAC PROCESS

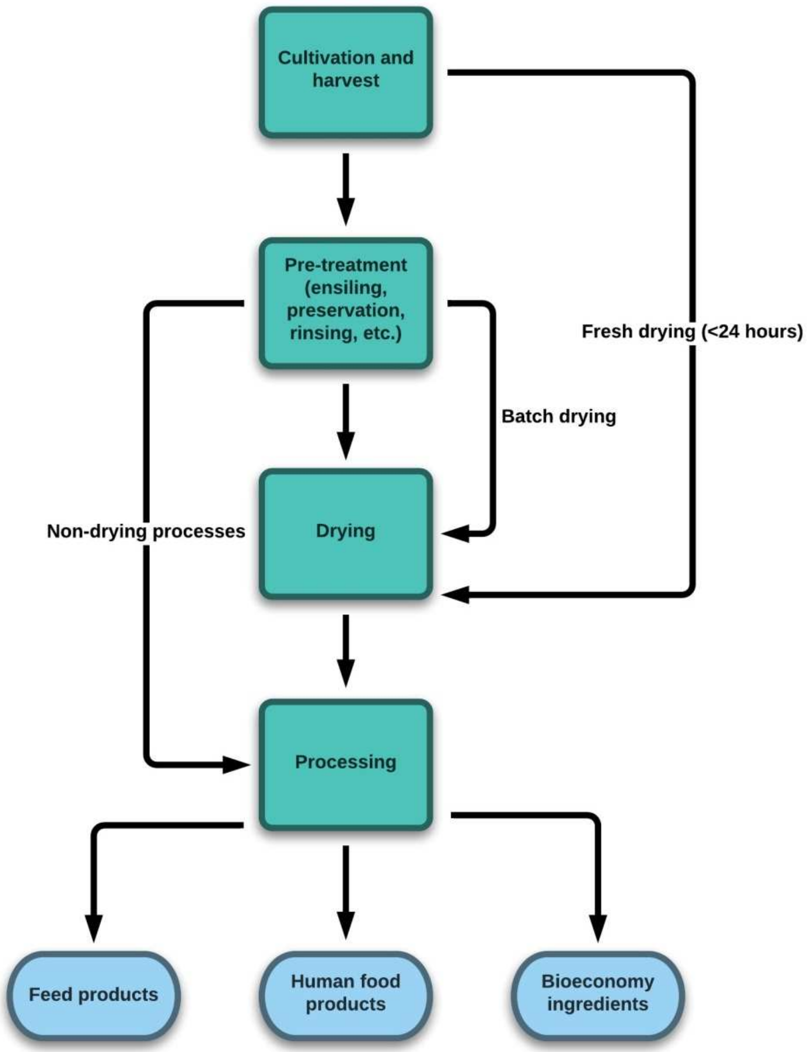
Production in five Norwegian reference facilities

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.

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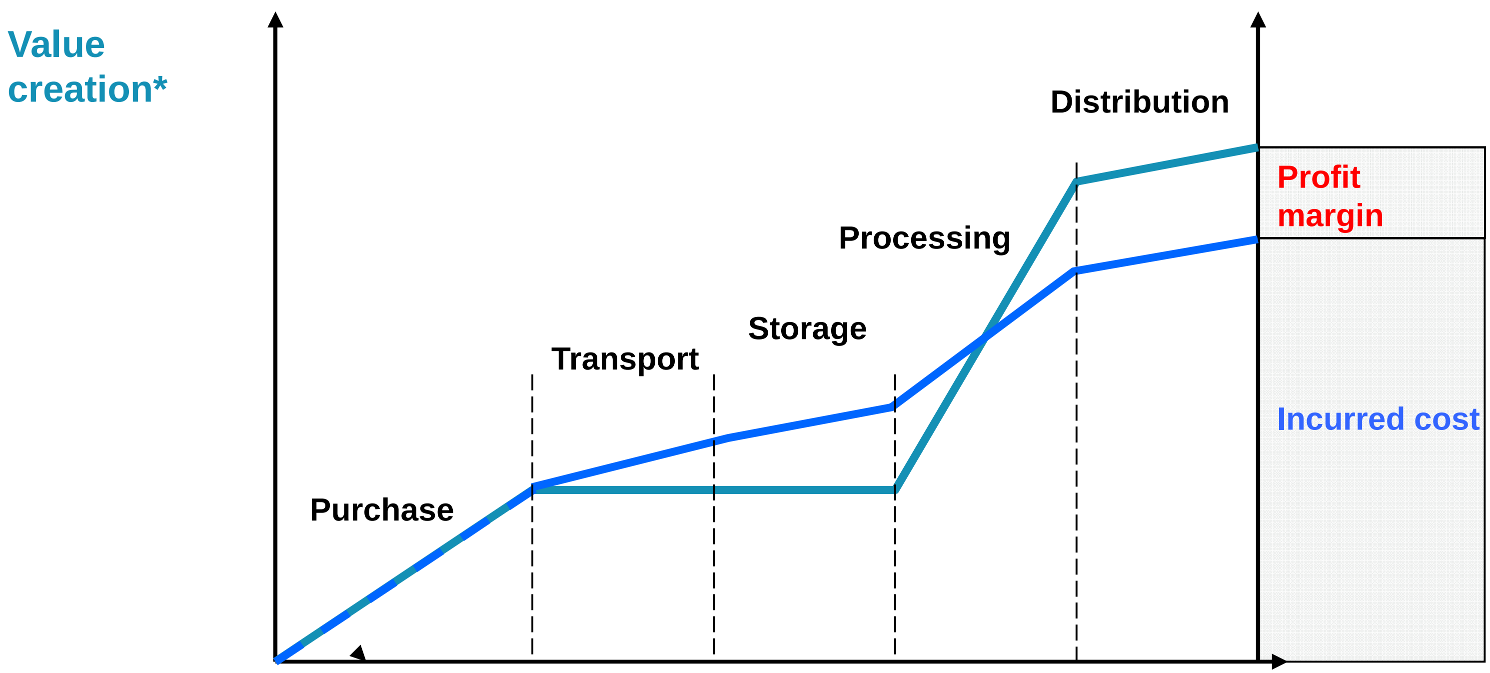
Incurred Cost Value creation Value capture



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