ZEEWIER POTENTIE NOORDZEE

platform duurzame biomassa | Jaap W. van Hal

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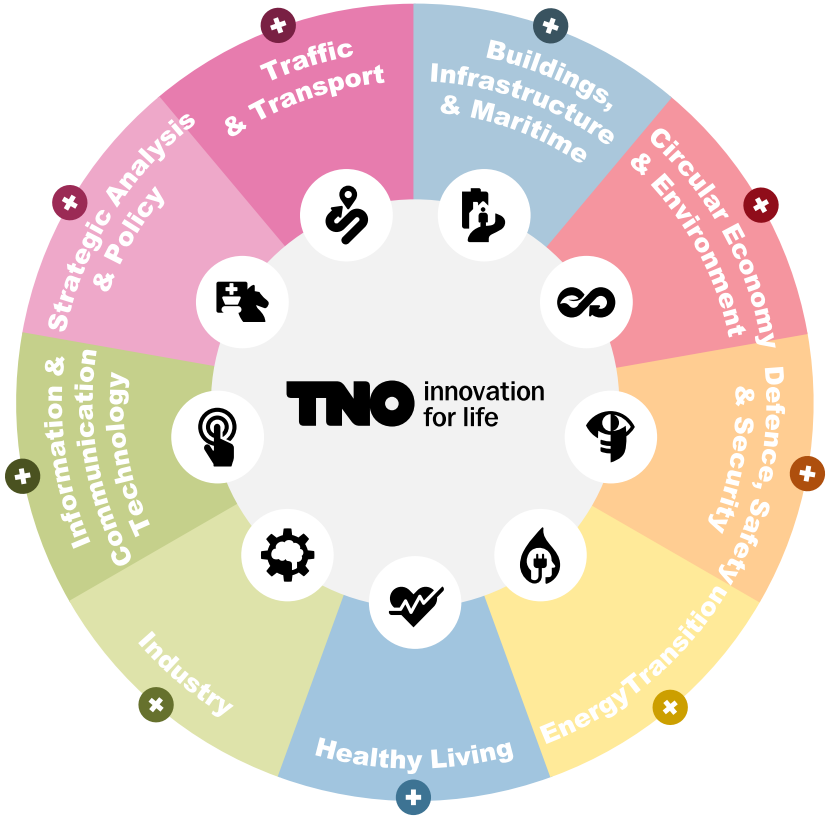
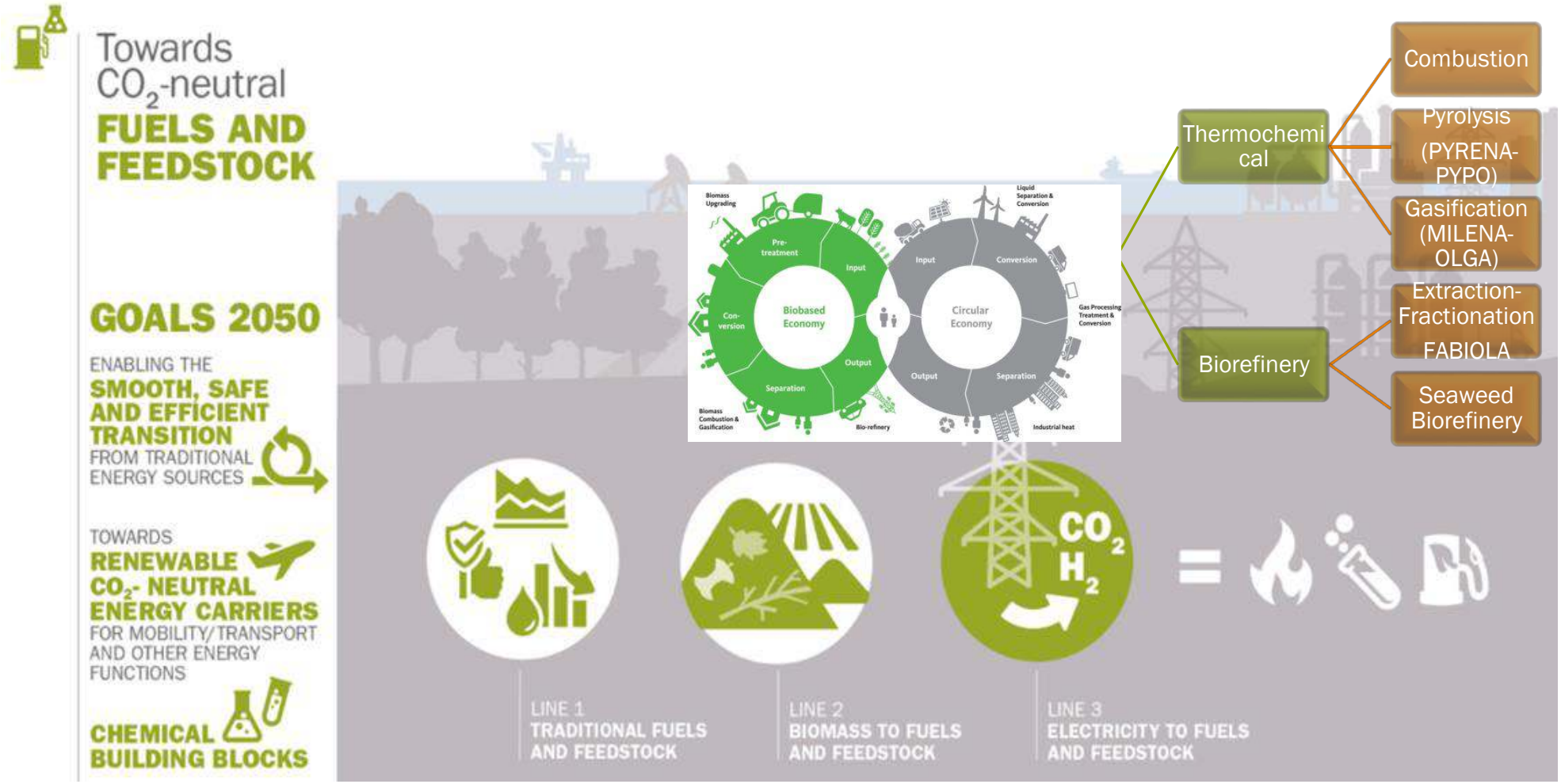
TNO
WHO WE ARE?



TNO ENERGY TRANSITION



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PARTS OF SEAWEED

SEAWEED SPECIES NATIVE TO THE NORTH SEA

Saccharina latissima

Laminaria digitata

Laminaria hyperborea

Ulva sp.

Alaria esculante

Palmaria palmata

DIFFERENCES BETWEEN LIGNOCELLULOSIC AND SEAWEED BIOMASS

- Lignocellulosic biomass:
- Cellulose
  - Extremely recalcitrant
- Lignin
  - Heterogeneous polymer
    - Species, source and time of harvesting dependent
- Hemicellulose
  - Easy to hydrolyse
- Ash
  - Low to high
- Overall composition reasonably stable

Seaweed biomass

Carbohydrates

- Type dependent on species
- Amount dependent on season and location

Proteins

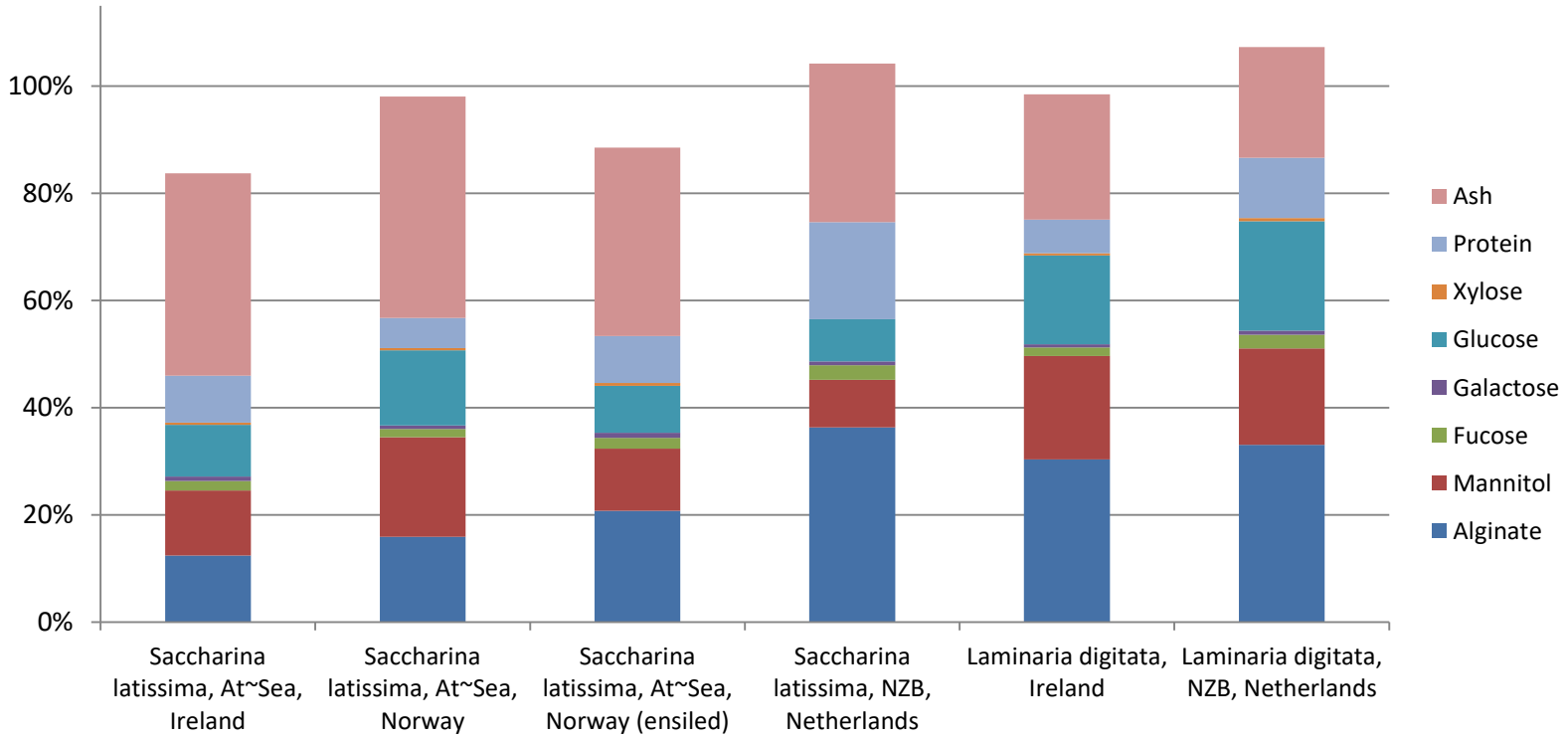
- Aminoacid composition dependent on species
- Amount dependent on season and location

Ash

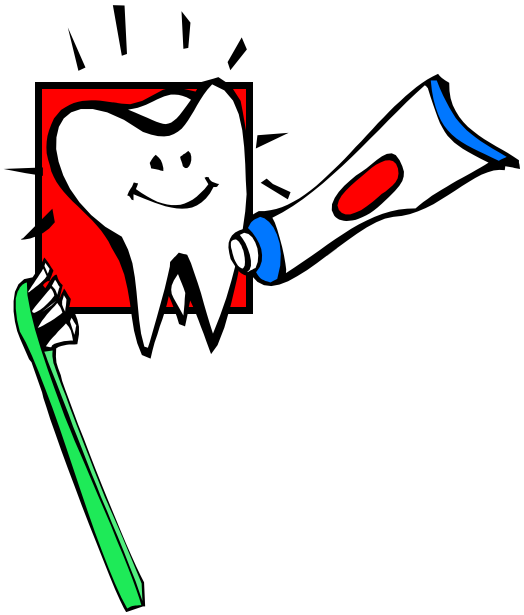
- Species dependent
- Amount dependent on season an location

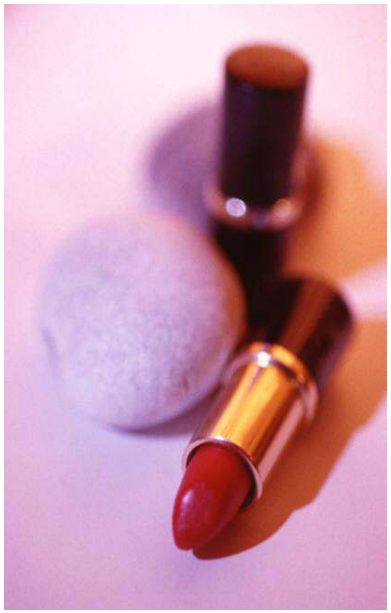
Extreme differences between seasons

LOCATION LOCATION LOCATION



SEAWEED IN EVERYDAY PRODUCTS





SEAWEED IN FOOD

SEAWEED IN YOUR MOBILE

SEAWEED CULTIVATION

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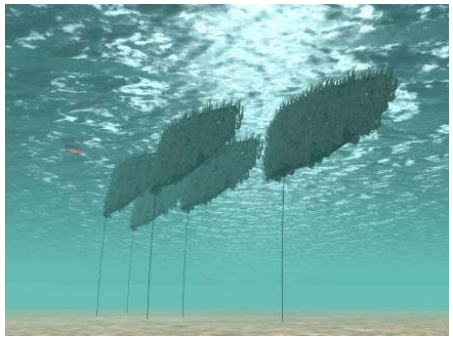
SEAWEED CULTIVATION SYSTEMS UNDER DEVELOPMENT



SES

Inrada

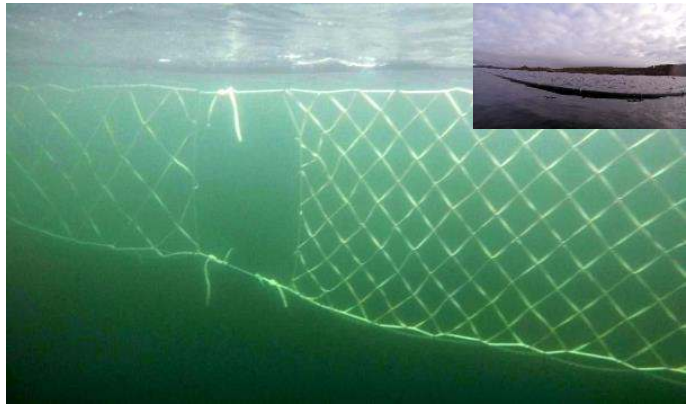
Ocean Rainforest

At~Sea technologies

Stichting NZB

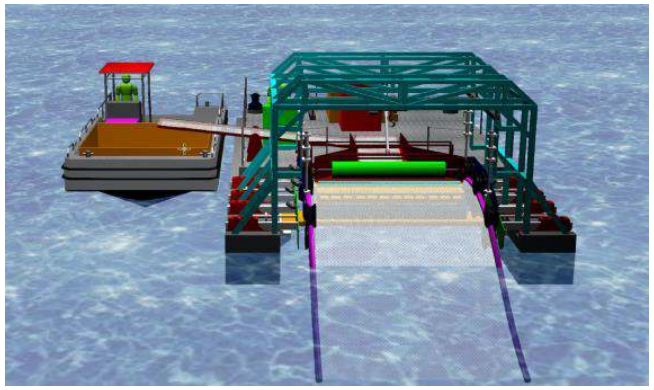
SEAWEED MECHANISED WILD HARVEST

ADVANCED CULTIVATION IN SCOTLAND



DRYING THE HARVEST IN SCOTLAND (2017)

MECHANISED HARVESTING



ENSILING ON LAND

THE DUTCH SEAWEED PROGRAMME

- Seaweed cultivation area 14,000 km^2 (cf. NL area of the North Sea @ 57,000 km^2)
- Integration with off-shore wind parks & (other) aquaculture operations
- Theoretical energy potential up to 350 PJ_{th} (25 Mton dry biomass per year, 5,000 km^2)
- Report: ECN-C—05-008
- Carrying capacity: ????

THE DUTCH SEAWEED PROGRAMME IS:

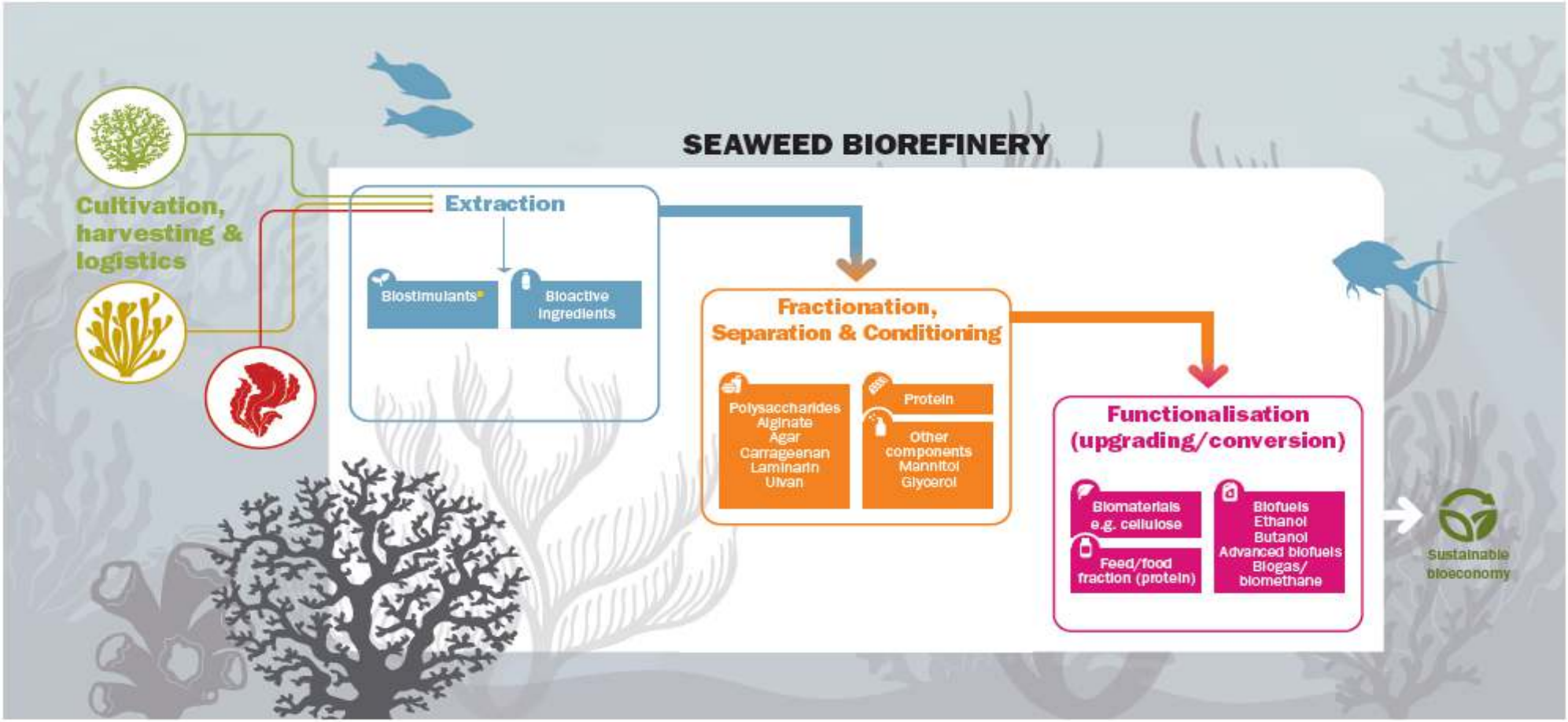
- Combines the 5 (now 4) applied research centres in the Netherlands with sea research centres
- Aims at developing a comprehensive integrated research agenda
- Starts with seaweed as food programme
- Covers divers subjects such as spatial planning, multi-use of the sea, etc.
- Implemented in the National Programme (MMIP 12 D, English version available upon request)

TOWARDS A 100 HA DEMO MULTI USE PRODUCTION UNIT

- Practical implementation of the multi-use procedure
- https://www.noordzeeboerderij.nl/en/projects/multi-use-procedure
- Produce sufficient seaweed for large scale product demo
- AND
- Accurate determination of the effects on the environment
- Synergies with the other users
- Seaweed for materials, chemicals and energy carriers in the later presentation

Lacroix, Denis & Pioch, Sylvain, 2011

FROM SEAWEED TO VALUABLE CHEMICALS, FOOD AND FUELS



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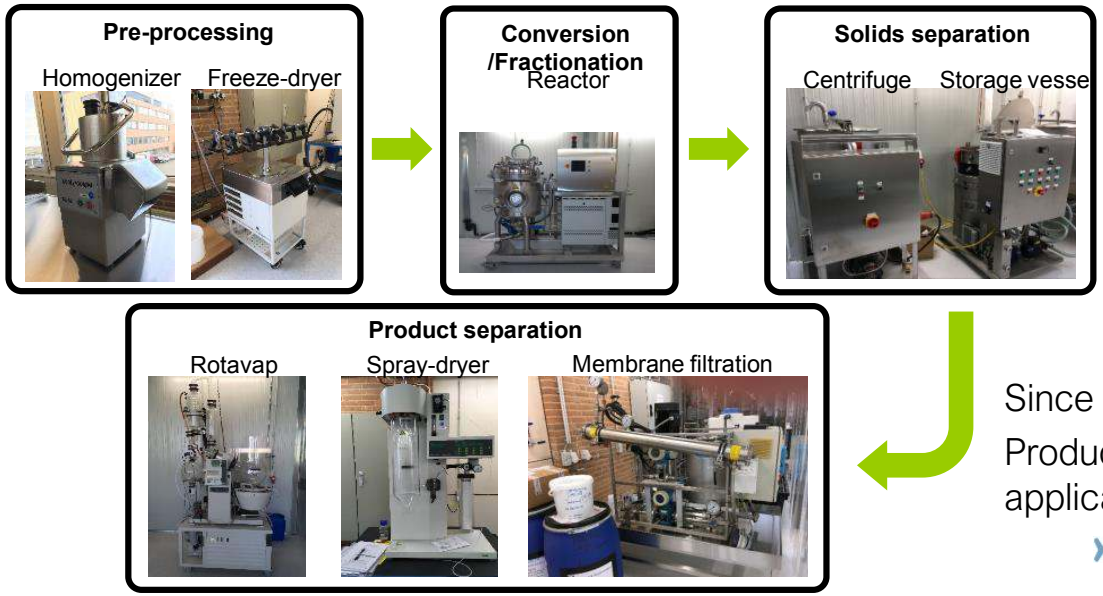
SEAWEED BIOREFINERY LAB – PETTEN, NL



Brown	Green	Red
Alginate (uronic acids)	Cellulose (glucose)	Carrageenan (S-galactose)
Fucoidan (S-fucose)	Ulvan (rhamnose-uronic acids)	Floridoside (gal-glycerol)
Laminarin (glucose)		Xylan (xylose)

Since November 2019

Production facility for fractions (intermediates) from seaweeds for application tests:

- Seaweed fractionation 100 L autoclave reactor – Mannitol stimulants, enzymatic hydrolysis, sugars
- Modular / flexible unit.
- From brown, red and green seaweeds to monomeric sugars (later expansion to co-products).
- 1-5 kg scale demonstration – Seaweed hydrolysis, sugar conditioning, glucoside esters production, product purification

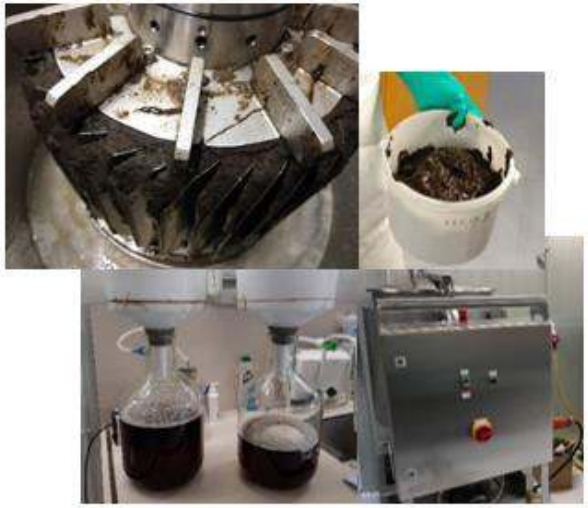
https://www.youtube.com/watch?v=Yb9JApeb7Bw

PRODUCING SUGAR SYRUPS

Day 1
Reaction in vessel

Slurry = 100L
Start = 5 kg dry seaweed

Day 2-3
Centrifugation/ filtration (>25µm)

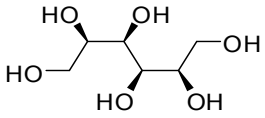


Solid recovery ≈ 1.5 kg dry
Liquid recovery ≈ 80 L

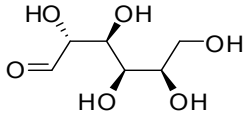
Day 4
Membrane filtration

Sugar concentration ≈ 200%
No increase of K/Na content

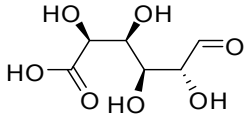
ULVA (GREEN SEAWEED)



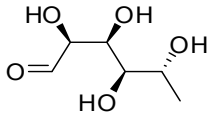
mannitol



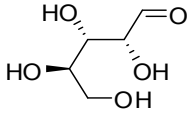
glucose



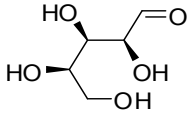
glucuronic acid



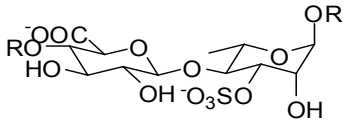
rhamnose

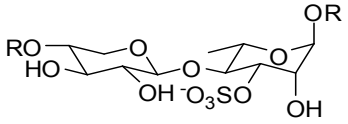


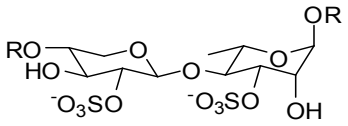
xylose

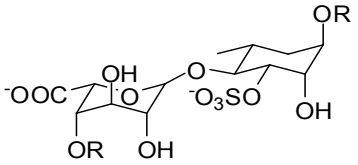


arabinose



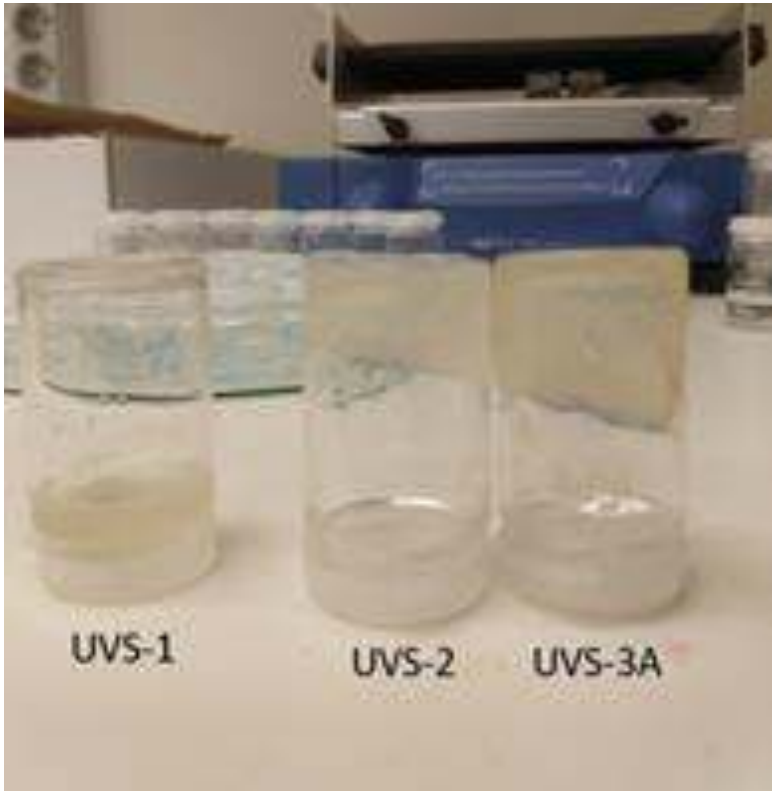






Ulvans

ULVAN



NANO CELLULOSE

FEEL FREE TO CONTACT ME!

http://www.herewear.eu/
http://www.macrofuels.eu
http://www.macrocascade.eu
http://www.noordzeeboerderij.nl
https://port4innovation1.nl/

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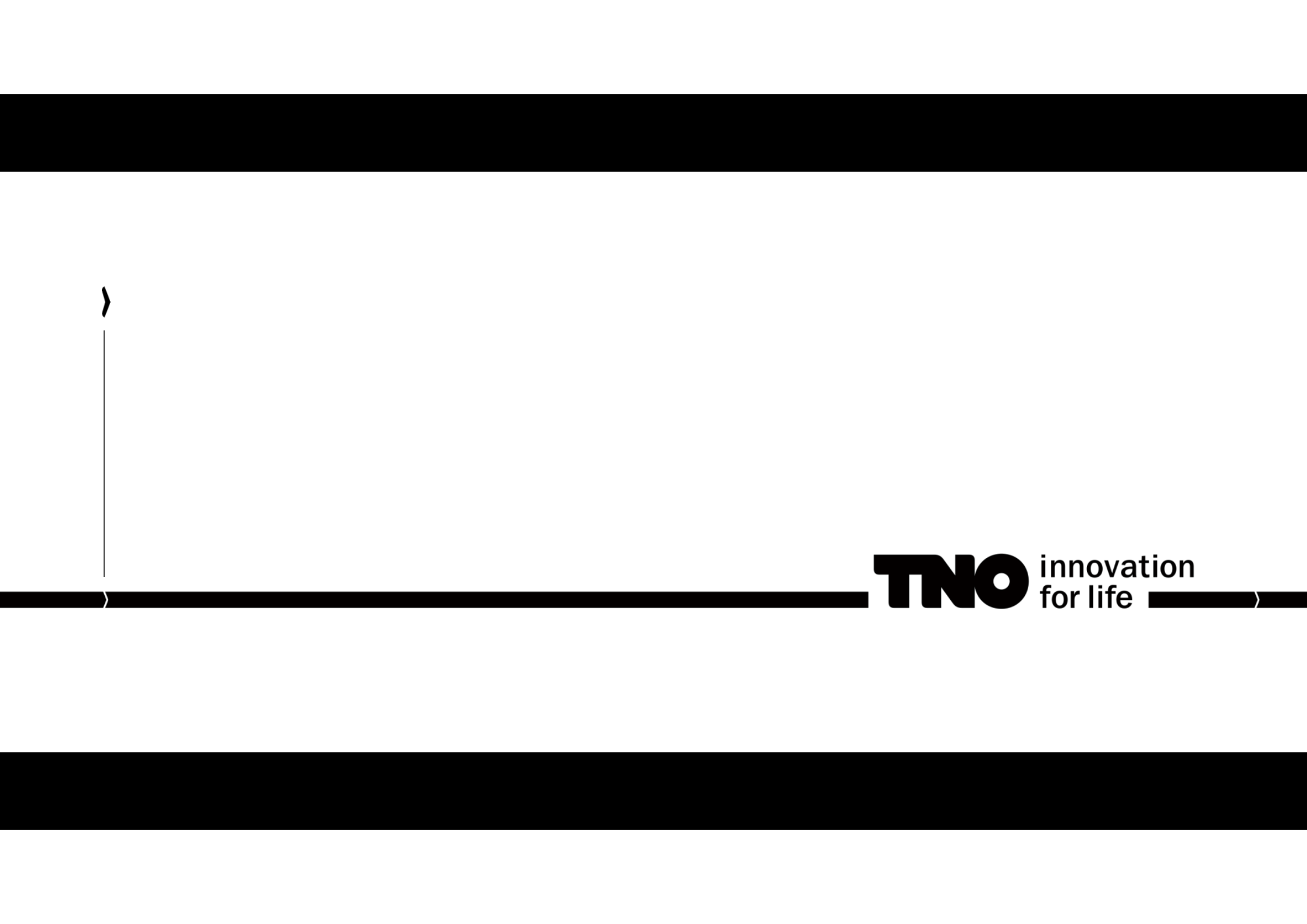
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