20 FÉVRIER 2023

BDI-2021-ICE (II) – INDUSTRIAL PILOT TO VALORIZE CAST SEAWEEDS ON ISLE OF WIGHT (UK)

JEAN-BAPTISTE WALLAERT
JBW CONSULTING

TABLE DES MATIERES

I. SERVICES

A. Coordination

1. Update on progress - valorization

Following the first economic feasibility report of 2021, we retain 4 valuation possibilities according to the state of maturity of the Isle of Wight. We exchanged emails between July and December 2022 without however leading to a pilot within the time allowed.

a) *Compost & biostimulant*

Before considering a biostimulant pilot in England, I offered to bring some biostimulant from a pilot project done in France. There are some on the market in England to which farmers can actually testify.

b) *Biomethane + heat + electricity + compost*

Testing protocole was sent oon july 28th (annex 3) was discussed this autumn with Black Dog and lately with the cooperative IW grain.

c) *Coastal erosion protection*

With a minimum of transformation, it is this valorization that makes it possible to process the seaweed on the coast with a minimum of transport but a uniquely and exclusively ecosystem

advantage. No direct economic value is calculated but the demonstration of the costs due to coastal erosion seems obvious nowadays unfortunately.

: Deux types AlgoBox® installés en juillet 2014 sur la plage de Penvins dans le Morbihan, France (**a** et **b**) ; échouage massif d'algues rouges et remplissage des AlgoBox® avec *S. chordalis* (**c**) ; colonisation des AlgoBox® par la végétation (**d**) (Sedrati et Cochet 2015).

Figure 1: algobox

2 types of Algobox installed in July 2014 on Penvins beach, Morbihan (fig A and b). Massive cast red seaweed in algobox with Solieria chordalis (fig c), colonization by plantations (fig d)

d) *Collection and silage*

This step is the prerequisite for the first 2 recovery methods: composting and production of bio methane. At this stage, contacts are established with the Scottish Association for Marine Science, holder of patents on silage.

2. Interest in the energy independence of the islands

Together with a tool for calculating the energy potential of the islands, this ICE project was presented at the 3rd Virtual Island Summit on September 29, 2022 on the theme: "Bio economy for islands: how to valorize your wastes and produce energy?

In addition to the conclusions of the report presented at the end of 2021, we have produced a business model that is not yet profitable, of course, but in an environment that makes it more and more believable.

Take away

- Seaweed is not an energetic biomass
- But seaweed can be digested
- Economic ratio is unbalanced between community and private sector
- Actual energy price and technical feasibility deserve interest

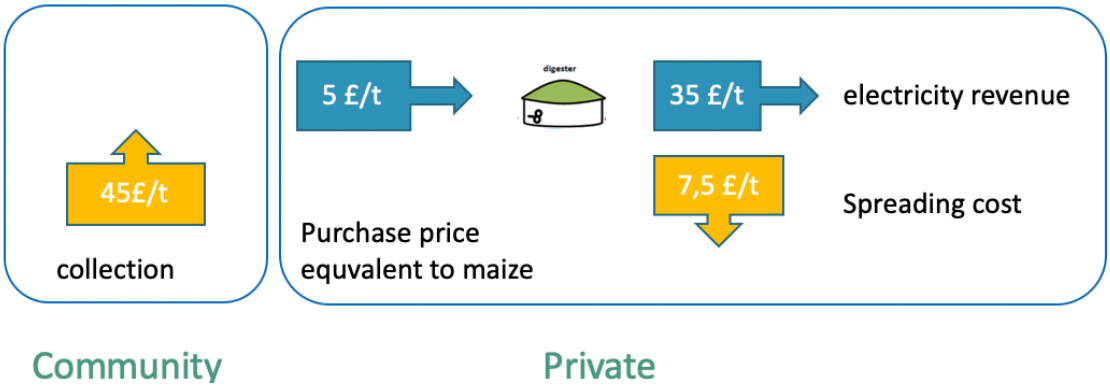

Figure 2: Take away du Virtual Island Summit 2022

B. Technology Readiness Level (TRL)

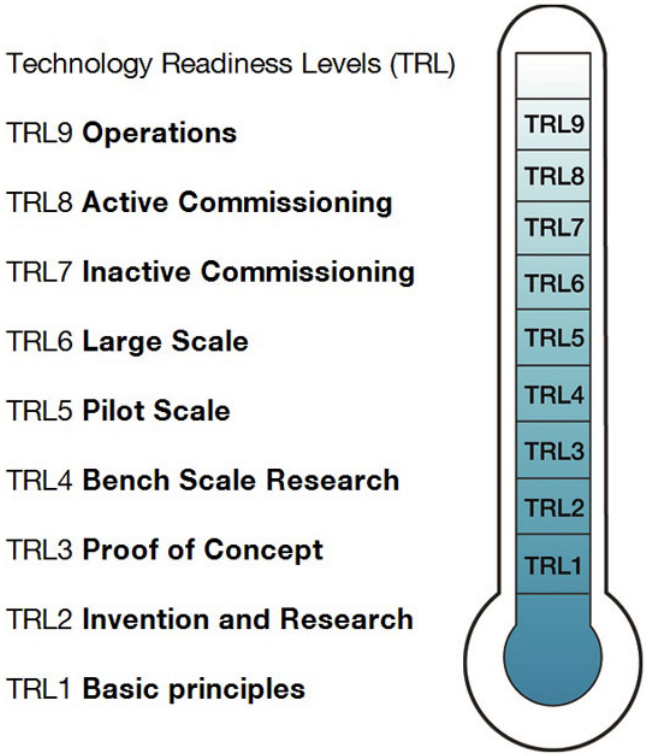

Figure 3TRL levels by www.gov.uk

1. Progression TRL (Technology Readiness Level)

In July 2022 with Inovalys' analysis we demonstrated the potential of bio methane in algae and ensured the TRL 4: validation of the technology in the laboratory.
During its operational phase, the project encountered an unavailability of anaerobic digestors (AD) to carry out tests.
Of the 2 AD we met in 2021, we did not have a response from White farm and despite an advanced process of discussions with Black Dog, we did not manage to agree on the integration of algae into the incoming mix, even after a proposal for laboratory tests at home.

See BlackDog's provisional refusal in Annex 4.

2. Pilot description

It consists of a collection and treatment protocol in order to integrate it into an anaerobic digester in experimental quantities.
See the protocol in Annex 3.

3. Note for digestor assessment

In order to prepare the digestate collection at the end of the process, a note had been prepared intended for the AD operator to identify the points of measurement necessary on the product and the impact on the fields.

	source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5706049/										source: CEVA						
mg/100g dry	K	Na	Ca	Mg	Fe	Cl				mg/100g dry	K	Na	Ca	Mg	Fe	Cl	
AN	3781.35 ± 13.40	4575.71 ± 50.05	984.73 ± 47.26	867.82 ± 12.01 [a]	13.34 ± 0.90	3079					2144	2871	1601	831	19	3079	10545
FV	3745.05 ± 36.01	2187.51 ± 36.90	1160.27 ± 23.10	732.37 ± 5.35)	18.99 ± 0.32						2654	3238	1187	661	14	3079	10833
3T at 30% (equivalent for 1T dry)																	
in kg/T dry	K	Na	Ca	Mg	Fe	Cl	TOTAL				K	Na	Ca	Mg	Fe	Cl	TOTAL
AN	37,81	45,75	9,85	8,68	0,13	30,79	133,01	50%	66,505		21,44	28,71	16,01	8,31	0,19	30,79	105,45
FV	37,45	21,87	11,6	7,32	0,19	30,79	109,22	50,00%	54,61		26,54	32,38	11,87	6,61	0,14	30,79	108,33

Figure 4: calculator for minerals to be spread

Voir la note en Annexe 6 : Note for pilot test in AD plant

4. Progress with the Isle of Wight county

Following the presentation to Council in January 2022, Isle of Wight County we have been working on booking a budget to collect and transport seaweed.
See the "briefing Note" in Appendix 2.

For a proposed budget of £15k, it was agreed to scale the test to 300T rather than 1000T.

1 load			7 T					
		To	Black dog-Stag Lane	WhiteFarm - Arreton				
WITHOUT SWD								
intrant capacity T/ day			60	145				
intrant capacity T/ year			21000	50750				
WITH SWD	with ensiling		21%	11%		spread 100% volume along the 12 months		
intrant capacity T/ day			13	16				
intrant capacity T/ year			4410	5582,5				
WITH SWD	no ensiling		39%	22%		concentrate 100% volume in 5 months		
intrant capacity T/ day			23	32				
intrant capacity T/ year			3510	4785				
unit price (£) per load	From		£/load	£/load	£	quotation Q800/KGC/PAS from Kevin		
	Sandown		200	150				
	East Cowes		200	150				
unit price (£) per day		1050						
	£/d	T/ load	loads/d to Black D	loads/d to White F.	£		tons	£/t
day 1 - Sandown	1050	7	2	5	2200		49	
day 2 - Sandown	1050	7	2	5	2200		49	
day 3 - Sandown	1050	7	2	5	2200		49	
day 4 - East Cowes	1050	7	2	5	2200		49	
day 5 - East Cowes	1050	7	2	5	2200		49	
day 6 - East Cowes	1050	7	2	5	2200		49	
TOTAL		7,5	12	30	13200		294	44,9
Ratio swd/intrant			25%	26%				

Figure 5: logistic spread for the test

ICE-2022 Seaweed logistics.xlsm

C. Conclusions

This project continues beyond the intended duration for project as long as the initiatives for valorization progress, energy costs increase and the nuisances of the algae continue to breed hope to valorize them locally.

The economic conditions are not yet met to propose a profitable business plan that takes into account all the necessary steps for the proper treatment of algae.
Up to now, for £15k invested in collecting algae, the return is only approaching £10k.

Although the in situ trip remains, it is clear that the desire to promote algae is exposed to economic reality and the prioritization of English partners. Efforts to bring together the actors of Black Dog, IoW Council, IW Grain (agricultural cooperative) maintain the momentum but the timing of implementation has not allowed to be fully adjusted with the timing of the report of this project.

Coming spring can trigger a new opportunity to test the valorization in agriculture.

II. ANNEX

1. Annex 1: QUOTATION FOR COLLECTION

K COGHLAN PLANT & TRANSPORT LIMITED

Pound Cottage, Pound Lane
Calbourne, Newport,
Isle of Wight. PO30 4JX.

Email: kevin@kevincoghlan.co.uk

Plant Hire
Haulage

General
Contractor

TELEPHONE: (01983) 531837

MOBILE: 07973 317 248

FAO: Jean-Baptiste
JBW Consulting SAS
Email: jbwallaertconsulting@gmail.com

Q800/KGC/PAS

02/09/2022

Re: Seaweed Removal

We have pleasure in submitting our quotation for the following as discussed earlier:-

Machines
Telehandler & Operator
ZX130 Excavator & Operator
Banksman
Welfare Van
For The Sum Of £1,050.00 Per Tide
Please note these rates are based on normal working hours 07.30 to 17.00
Rates charged after are charged at the following:
17.00 to Midnight – Time & Half
Midnight to 07.30 – Double Time

Haulage
Sandown Beach to White Farm Arreton @ £150.00 Per Load
Sandown Beach to Black Farm Stag Lane @ £200.00 Per Load
East Cowes Beach to White Farm Arreton @ £150.00 Per Load
East Cowes Beach to Black Farm Stag Lane @ £200.00 Per Load

This quotation is valid for 3 Months Only
If you require any further information please do not hesitate to contact me

Yours sincerely

K Coghlan
Director

K Coghlan Plant & Transport Limited – Registered Office: c/o AH Cross & Co, 16 Quay Street, Newport
Isle of Wight, PO30 5BG
Company Registration No. 06839756

2. Annex 2: Briefing note

EU seaweed project - valorisation trial **Briefing note**

Background

A report was considered by the Harbour Committee on 12.01.2022 regarding the above; members were advised that a piece of work has been jointly commissioned by the Isle of Wight Council and Ventnor Town Council to look at possible alternative uses of seaweed in Ventnor harbour and areas of foreshore leased or owned by the Council.

The work was undertaken by JBW Consulting through a European funded programme called ICE; their presentation is attached as an appendix and as can be seen this included, the scope of the project, quantities of seaweed around the Isle of Wight and details of samples taken for analysis, was circulated to members in advance of the meeting. Jean Baptist (JB) from JBW ran though the report and took questions.

It was agreed that officers would take the report back to discuss how the issue could be delivered. Accordingly, officers have been in contact with JB to discuss a way forward.

The recommendation from JB is to undertake a pilot scheme which would see seaweed removed from two key locations and taken to anaerobic digesters (AD) and this would establish the feasibility for a full scheme.

It is therefore proposed to use a local contractor to remove approximately 350 tonnes of seaweed from East Cowes and Sandown beaches; this would be spilt approximately 50/50 and taken to each of the two AD plants. Whilst larger quantities would be preferable such a pilot could be delivered for **£15k.**

The aim of the pilot would be to enable the AD plants to review and potentially adjust their processes to be able to effectively deal with seaweed and would ensure that it is technically viable before considering a full scheme.

Clearly seaweed is the result of natural phenomenon quite often combined with human activity where it impacts on natural processes (i.e., construction of marine facilities on areas of foreshore) and this can require removal and disposal to avoid a nuisance being created due to decomposition and odours.

The aim of the trial is to demonstrate that seaweed can be collected, processed and converted to energy through existing AD plants on the Isle of Wight Council.

For the purposes of the trial (and based on previous research) it is assumed that:

- 1 kg seaweed VS generates 200l/kg VS of methane => 1T seaweed (14%DM) generates 18m3 CH4.
- 1m3 methane delivers 10 kWh
- 1t seaweed fresh (15% DM) generates 180 kWH HHV
- 1 MWH has a value of £55 to £108 (depending on tariffs for each site)

VS = volatile solid; DM= dry matter; CH4=methane

Financial impact

There is currently no budget available to remove seaweed from Isle of Wight Council managed beaches; accordingly, the cost to remove seaweed either as part of pilot or a full scheme would be an additional cost. However, there is an opportunity to sell seaweed to an AD plant and obtain an income form the energy generate; for the pilot this will partially offset the costs to collect, dry and transport the seaweed.

Based on figures collated by JBW the following is considered reasonable for the pilot: -

Activity	Milestone	£
Collect 350 tonnes fresh (15% dry matter) seaweed @ £45/t	- Sun drying efficiency - Ensilage quality - Storage capacity	15,750
Sell 175 tonnes dry (30% dry matter) seaweed to AD plant @ £5/t	- Inhibition inactive - Sand content	-875
Cost for 21T digestate spreading and agronomic value @ £2t	- Existing AD plants, including R&D - Partnership contract	42
Produce energy from 175 dry tonnes	- Investigate further a mix with household waste	-9,925
Total (net)		**4,908**

Options

1. Agree to fund the pilot scheme to assess the technical viability of removing seaweed form Isle of Wight Council beaches which can be processed at AD plants and converted to energy. Cost £15k

2. Ask East Cowes and Sandown Town Councils to fund £7.5k each to cover the cost of the pilot.

3. Ask East Cowes and Sandown Town Councils to fund £5k each with the remaining £5k being funded by the Isle of Wight Council.

4. Agree not to proceed with the pilot scheme.

3. Annex 3: Protocol

Protocol sent on July 28th 2023 :

BDI-ICE 2022 - protocole.docx

This project is the 2nd phase of previous project BDI 2021-ICE completed in December 2021 and reported in January 2022.
ICE project aims at identifying all sources of energy available on isolated territories in order to propose a method to gain in autonomy.

Project Objective:
Assess the technology readiness level 5 and improve to TRL 6 and 7 by operating a pilot in existing installations identified to process seaweeds
The pilot would treat 1000T of the 18,500T available per year on Isle of Wight.

I. PROTOCOLE

A. Objectives

- Identify financial conditions to make seaweeds collection, treatment, purchase acceptable for energy + fertilizer valorization
- Understand technical requirements such as
  - Sulfate content
  - Polyphenol concentration
  - Salt concentration
  - Inoculum quality
  - Hydrolysis temperature
  - Integration mix into existing crop mix
- Measure biomethane potential (BMP) under different mix. This is to evaluate the methanogenic reaction, its parameters.
- Differentiate yield according to the season. Low carbohydrate is expected in spring. Therefore the autumn collection would be ensiled for all year round operation.
- Assess full usage of the biomass until land spreading or composting

B. Process

According to project report deliverable (ICE-IOW Lot_Energy_2021-08-24_summary – p6)

COLLECTING
collection in water in order to avoid to meanwhile collect ashes
⇩
WASHING
if collected on sand, washing may be advised to remove ashes
⇩
DRYING
passive drying like sun-bathing over 2/3 days drying with free heat coming from a CHP for example
⇩
CHOPPING
rough chopping would increase significantly the methane yield, avoir pumping failure, ease storage
⇩
DEWATERING
auger pressing would remove about 10-15% of water content and 30% of ashes
⇩
TRANSPORTATION
removing the most water possible before transportation would reduce costs

⇩
STORAGE
algae may be ensiled and stored so that the AD plant can be fed continuously over the year
⇩
AD PLANT FEEDING
proportions of daily feeding have to be assessed so as not to inhibit the methanogenic reaction

C. Cost and revenue

Assuming :
1T seaweed content 15% dry matter. 60% of DM is volatile solid (40% is mineral). 55% of VS is methane.
1 kg seaweed VS generates 200l/kg VS of methane => 1T seaweed (14%DM) generates 18m3 CH4.
1m³ methane delivers 10 kWh
1t seaweed fresh (15% DM) generates 180 kWH HHV
1 MWH = 55 to 108 £ depending on tariffs for each site

COST	Phase 1 (£ / t fresh seaweed)	Phase 2 - tbd
Collecting – handling - rinsing	26	
Transporting	13	
Chopping	6	
Ensiling	30 (for 50% of the volume)	
Land spreading	2	
TOTAL	62	

REVENUE		
Energy	11 to 20	
Crop saving	5	
Nitrogen extra	0,8	
TOTAL	16,8 to 25,8	

Need in funding range : 36,2 to 45,2 £/T for 1000T.
A 45,000£ funding will be necessary to handle 1000T of seaweeds and compile feasibility of the pilot.

II. OPERATIONS

A. Lab Test

August – september
Run BMP test in lab, similar to operations consuming fresh seaweeds
Quantity to be decided according to lab capacity.
Collection of 1 shot of seaweeds, kept frozen, added daily in the reactor at 5% of the mix.

B. Pilot test

October - november
Prepare 120T/ week of swath rinsed

4. Annex 4 : Black Dog refusal

a) *Proposal to meet in January 23*

Mark Ridett <mark@staglanebiogas.co.uk> 14 déc. 2022 11:54
À moi, Craig, Paul

Détecter la langue > français Traduire le message Désactiver pour : anglais

Hi Jean - Baptiste,

I'd be happy to meet you in January but I am a little unsure as to what exactly you want from us at this stage ?

My main priority is maintaining biological stability in the digesters and wouldn't want to do anything to jeopardise that as we are a commercial organisation which needs to operate at maximum capacity whenever possible,

regards,

Mark Ridett - Plant Manager

b) *agenda*

JBW Consulting <jbwallaertconsulting@gmail.com> 6 janv. 2023 09:36
À Mark, Craig, Paul

Dear Mark
Happy new year to you and your team !

I understand we can't use the facility as a test unprepared.
To optimize the trip I suggest
- test with freshly prepared seaweed (rinsed, cut) with your lab a Biomethane potential test with 5%, 10%, 15% incorporation. **Could you arrange availability with your lab to organize this protocole ?**
- meet farmer to test ensiling with fresh seaweed I will have collected during the trip (300t) and digestate data sheet.
Do you think you could involve your farmer partner in this ensiling test ? I can bring knowledge from institutes if needed.

Today seaweed are not competing maize but can be seen as a rescue in case of..
The day we're advanced to process 18,000T yes it will compete but time to open a new facility together with industrial waste. I still see discussions as preparing the future.
Sean Newton from IoW council is on a good way to get funding for the pilot test and he will announce there will be no over cost for you. That's why I can propose to move forward.

Cordialement,

Jean-Baptiste W.

c) *unavailability*

19/02/2023 15:52 Gmail - [ICE] Preparation webinar IOW

Gmail **JBW Consulting <jbwallaertconsulting@gmail.com>**

[ICE] Preparation webinar IOW

Mark Ridett <mark@staglanebiogas.co.uk> 6 janvier 2023 à 12:30
À : JBW Consulting <jbwallaertconsulting@gmail.com>
Cc : Craig Ibbetson <craig.ibbetson@sed-ltd.co.uk>, Paul Andrews <paul.andrews@sed-ltd.co.uk>

Hi Jean Baptiste,

We don't have a lab on site and would have to send any samples to the mainland for testing which is expensive.

We would consider purchasing the finished product in the future to supplement our feedstock but we don't have the time or resources to develop the product which may or may not come to fruition.

Our biologist is not keen on using seaweed but as I say it is something we may consider in the future as a refined feedstock we can have delivered to site and pay an agreed figure per tonne weighed over our weighbridge. Until you are at this stage we cannot assist further.

Can you ensure any future correspondence is directed to me only and not Craig and Paul,

Thanks and Happy New Year,

regards,

Mark Ridett - Plant Manager

5. Annex 5 : Bio stimulant interest

Gmail — JBW Consulting <jbwallaertconsulting@gmail.com>

FW: On a different matter....

3 messages

Fawcett, Jim <Jim.Fawcett@iow.gov.uk> 18 novembre 2022 à 10:53
À : JBW Consulting <jbwallaertconsulting@gmail.com>
Cc : "jack.hodgson@chevertonfarm.co.uk" <jack.hodgson@chevertonfarm.co.uk>, "Newton, Sean" <Sean.Newton@iow.gov.uk>, Peter Thomas <peter@iwgrain.co.uk>

Hi JB,

I had a very interesting conversation with Jack Hodgson yesterday and the answers to your questions, assuming I've noted what Jack said correctly, are as follows:

- What is the sodium content in soil where the digestate is spread ? It is not common for farmers to measure the Na content in their soils. Na has a detrimental effect on plant growth and, if there was poor growth of a crop, the level of Na might be determined to see if it was likely to be a cause. Jack is going to check a recent soil analysis for his farm to see if the Na content is shown; if so, this is likely to be representative of most farm soils as we can't think of any reasons for variation across the Island.
- What is the limit for Na content ? There is no specific limit set, it's really what is healthy for plants.
- What is the tonnage of digestate spread by hectare? This is determined by the organic nitrogen in the digestate which should not exceed 250kg N per hectare (although there can be slight variations on this depending on soil type). This equates to a total of 66 tonnes of digestate per hectare per year which is spread in two applications.

The farmers are actually looking at ways of improving the quality of the digestate through the addition of bio-stimulants. I know that seaweed products are often sold to gardeners as bio-stimulants and I wondered whether this was true and whether you can provide any further information to Jack on this aspect?

Best wishes,

Jim Fawcett| Principal Officer (Low Carbon Projects) | Regeneration

JBW Consulting <jbwallaertconsulting@gmail.com> 18 novembre 2022 à 15:56
À : "Fawcett, Jim" <Jim.Fawcett@iow.gov.uk>
Cc : "jack.hodgson@chevertonfarm.co.uk" <jack.hodgson@chevertonfarm.co.uk>, "Newton, Sean" <Sean.Newton@iow.gov.uk>, Peter Thomas <peter@iwgrain.co.uk>

Dear Jim,
Dear Jack, nice meeting you

I sincerely appreciate your answers and open mindset to put us through.

20/02/2023 15:46 Gmail - FW: On a different matter....

NITROGEN

- I fully agree with Nitrogen concern, and I've already discussed with BlackDog AD plant that the impact of Na will be minimum compared to N that will come first as limitation factor.
- From seaweed all N is not available for transfer. I have in mind that 30T/ha of seaweed cake from hydrocolloid extraction brings 140kg of N whom 50kg are available per ha. It's a start for AD digestate comparison.
- to compare, France has a similar limit to 200kg N/ha in cultivated land up to 4350kg N/ha in meadows. Of course other limits are also coming in dry matter, C/N ratio, heavy metals, dioxins.

BIOSTIMULANT

Regarding biostimulant, it is true that brown seaweeds offer real benefit. They contribute to activate self defence, by producing hormones to inform the plant to develop its own biology to fight.
Retails offers different products:
- https://www.gardenhealth.com/westland-specialist-seaweed-organic-liquid-feed
- same at B&Q and more..

The use of fresh seaweeds as source of organic matter and as fertiliser is ancient in agriculture, but biostimulant effects have been recorded and researched only recently. This prompts the commercial use of seaweed extracts and of purified compounds, which include the polysaccharides laminarin, alginates, ulvans and carrageenans and their breakdown products. Other constituents contributing to the plant growth promotion include micro- and macronutrients, sterols, N-containing compounds like betaines, and hormones. Several of these compounds are indeed unique to their algal source, explaining the increasing interest of the scientific community and of the industry for these taxonomic groups.

For our ICE project, as the raw material is stranded seaweeds and we have 2 AD plants, I walk toward compost and methane valorisation.

For another project I have in Brittany, the industrial has already an extraction process and I valorize the liquid into laminarin extract. I can bring you a sample and data sheet. Product is under conception and still a prototype. Goëmar, Agrocean, Tradecorp, Valagro..are some of the many companies on the market.

Looking forward to sharing more, especially if I manage to visit you before year end,

Best regards

JB

6. Annex 6 : Note for pilot test in AD plant

2022.11.18 ICE2 - Note to AD

November 13th 2022

NOTE FOR PILOT TEST IN AD PLANT

Prior to test a quantity of fresh rinsed chopped seaweed into AD plant we want to clarify implication in spreading the digestate

I. QUALITY OF DIGESTATE

A. Gas emissions

1. NO2

N_2O emissions are clearly correlated to the mineral N-content of the different soil amendments, being highest in the minerally fertilized treatment and lowest in the non-amended control and pure *Ulva* treatments. **No differences between the different concentration of ulva added in the manure slurry 20% and 40%.**
Source : Energy Production from Marine Biomass (*Ulva lactuca*) - PSO Project No. 2008-1-0050 , Nov2011

2. CO_2

As seaweed is wet, there is no high content of easily degradable organic matter as could be in the dried algae. **Digestate still brings around 40µg CO_2 / g dry soil** whatever the seaweed content (20% to 40%).
CO2 with mainly escape during biogas production.
Source : Energy Production from Marine Biomass (*Ulva lactuca*) - PSO Project No. 2008-1-0050 , Nov2011

3. SO_4^{2-}

When co-digested with manure the sulfate concentration of the mixture was well **below the SO_4^{2-} inhibition level** of 1.4g/L, reported by Siles (Siles et al, 2010).
Source : Energy Production from Marine Biomass (*Ulva lactuca*) - PSO Project No. 2008-1-0050 , Nov2011

Conclusion : The co-digestion of *Ulva lactuca* together with cattle manure does not alter the overall fertilization value and GreenHouse Gas emission potential of the digestate. However, some deeper insights in plant nutrient uptake and soil nutrient dynamics (including soil microbial biomass) are expected when all data are analysed

B. Chemical content

1. N,P,K

Contribution estimated per T of digestate :

parameter	Average (kg/T gross weight	availability coefficient %	available value (kg/ T gross weight)	Manure reference
N total	4,25	20	0,85	
P2O5	0,75	60	0,45	3,1
K20	8,7	100	8,7	8,1
MgO	3,6	100	3,6	
CaO	4,8	100	4,8	

Table 1

Our test will have to analyze how much the % of seaweed introduced impacts the % of N,P,K

2. Heavy metals and iodine

mg/kg dry	content	P	I	As total	Cd	Hg	Pb
	%	mg/kg dry	mg/kg dry	mg/kg dry	mg/kg dry	mg/kg dry	mg/kg dry
Ascophyllum nodosum	50	0,7 (<1)	487 (<943)	43 (<52)	0,25 (<0,39)	<0,1	<1
Fucus vesiculosus	40	1,34 (<2)	320 (<496)	53,6 (<74)	0,71 (<0,97)	<0,1	<1
Palmaria palmata	5	2,85 (<4,7)	167 (<802)	11,8 (<22)	3,17 (<59)	<0,1	<1
others	<5						
Limit (N F U 44-051) (concentration) Flow (g/ha)				<18 270	3 45	2 30	180 2700

Table 2 – average content and (maximum in brackets)

Source: Maximum value from QUALITALG, CSAVM 2021 – sampling done in 2020-2021 in Finistère (France) for 6 species from 9 locations.
We assume that absorption is physiologic and that water quality will affect similarly the seaweed during its lifespan.

3. Salts

mg/100g dry	content	K	Na	Ca	Mg	Fe	Cl
Ascophyllum nodosum	50%	2144	2871	1601	831	19	3079
Fucus serratus	40%	2654	3238	1187	661	14	
Limit (N F U 44-051) (concentration) Flow (g/ha)							

Source https://www.ceva-algues.com/en/document/nutritional-data-sheets-on-algae/

Assuming 3T of seaweed with 30% DM, this input will add 106kg of salts in the digestor.

If digestor > 3500l, concentration remains < 30 g/L which is suitable for degradation.
If digestor > 53m3, concentration falls to <2g/L which is suitable for land spreading.

RISK
Due to salts, pure seaweed land spreading is recommended every 3 years only.
After anaerobic digestion, we reduce significantly this risk of concentration.

BENEFIT
With seaweeds, the risk of integrating
Conclusion: Seaweed spreading dosage is usually around15T/ha, given by nitrogen.