BETA PROCESS bioenergy

DSD BV
DUTCH SUSTAINABLE DEVELOPMENT BV

ERA-NET Bioenergy

“From CHEMBEET via In NIJE DEI to Biethanol”
Seminar ACRRES - Lelystad

Hans van Klink, 4 July 2019

Content presentation

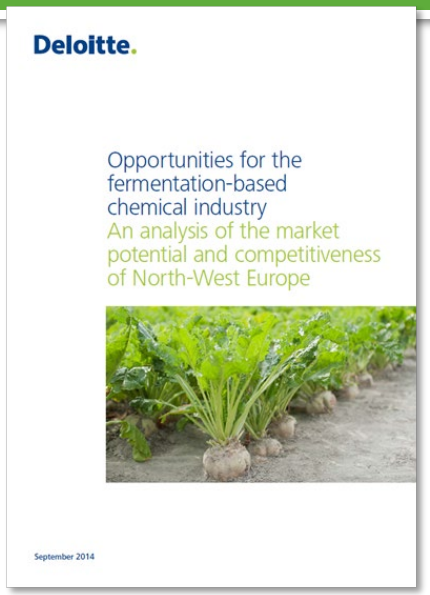
1. Background DSD;
2. Why sugar beet;
3. Direct Processing concept;
4. Fermentable sugars;
5. Conclusion;

Contact.

1. Background DSD / Betaprocess

Dutch Sustainable Development BV:

- Product and concept developer *(cradle to cradle)*;
- Background / history in sugar industry;
- Active with projects in the field of:
  - Sustainable agriculture;
  - Food processing industry;
  - Development sustainable agro business parks;
- Technology development, like **Direct Processing with Betaprocess**;
- Large network free lance specialists / expertise.



➢ DSD is the linking pin and concept developer between agro & chemistry and getting familiar with all issues in that chain.

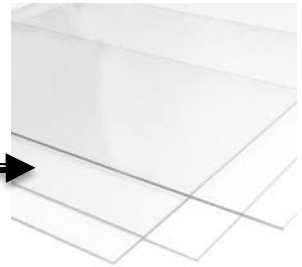
2.1 Why sugar beet?

WHITE SUGAR

NOT

BIOFUEL

ACRYLIC



DETERGENTS

COSMETICS

PHARMACY

PAINT

SOLVENTS

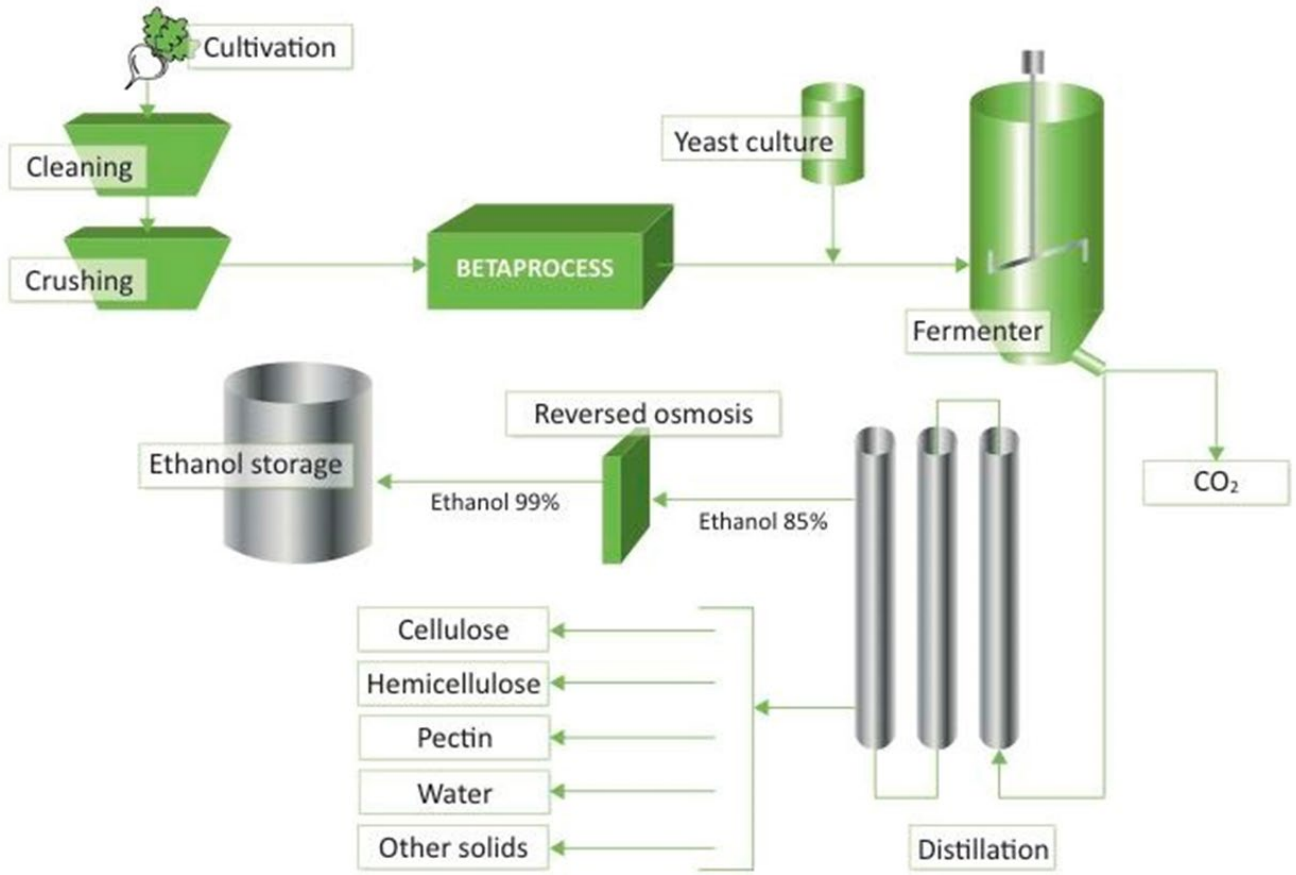
2.2 Why sugar beet?

- The ideal Biobased crop for:

1. Bulk chemicals → commodity chemicals, low added value;
2. Fine chemicals → small quantities, relatively high prices and “what it is” specification:
   - building blocks;
   - advanced intermediates;
   - active ingredients;
3. Specialty chemicals → specialties, effect chemicals, high value added to functional value, agrichemicals, essential oils, food supplements, ingredients for cosmetics and pharmacy.

→ Act as intermediates, significant ingredient in food, feed, pharma and cosmetics!

3.1 Direct processing with Betaprocess



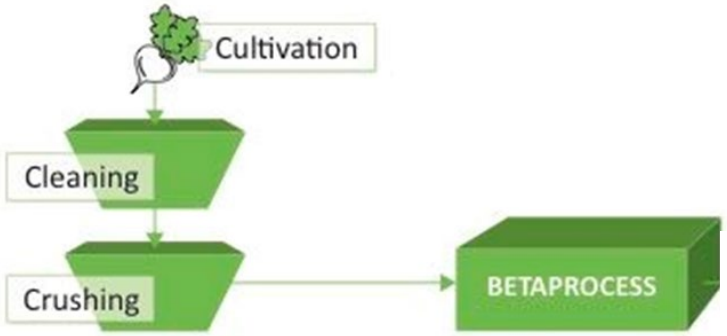
Fermentation:

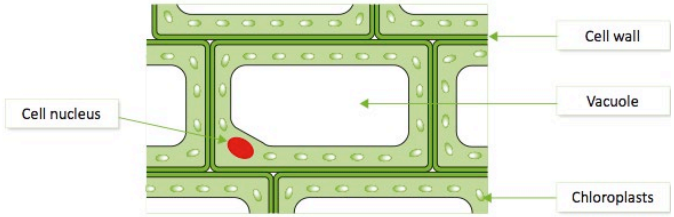
- Proven technology;
- After Betaprocess fermentation goes better, efficient and in shorter time;
- Higher yield: + 10 - 20%;
- Bio-ethanol: 10 – 20% lower investment costs than from corn/wheat;

- **Very pure CO2 side stream**

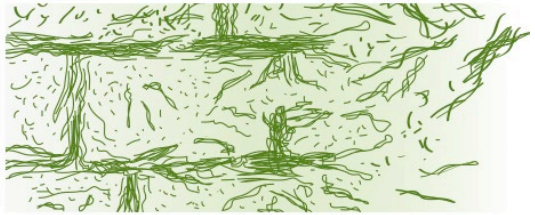
- More R&D running on use of pectin's, proteins and (hemi)celluloses.

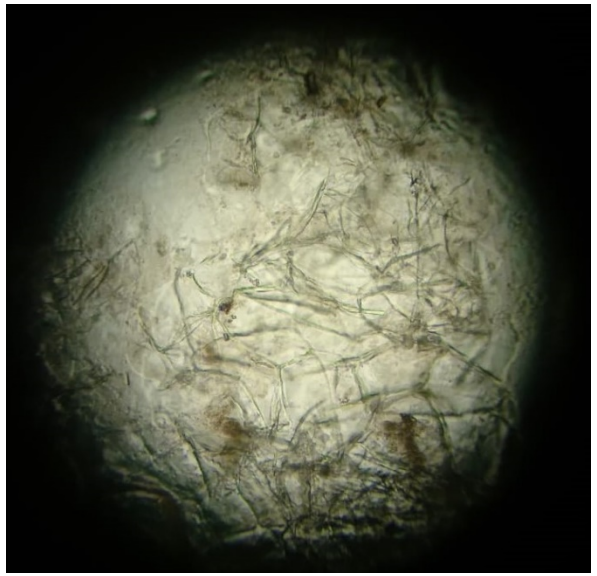
3.2 Direct Processing with Betaprocess





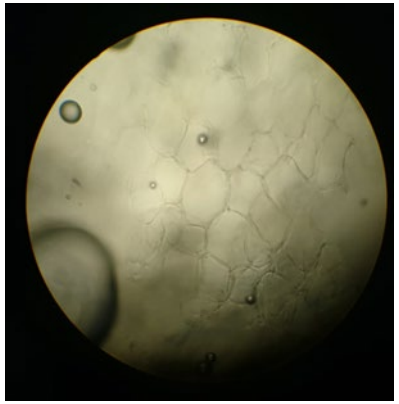
After Betaprocess





Betaprocess: opening cell walls by vacuum explosion:

- Much lower energy consumption than standard sugar technology;
- All fermentable sugars readily available;
- Fermentable sugars available for other fermentations or third partners.



3.3 Current Situation May 2019

CHEMBEET	In NIJE DEI	Biethanol
Eranet – Bioenergy	DEI	TKI-BBEGR
Jan. 2015 – March 2018	Nov. 2018 – June 2020	April 2019 – June 2020
Objective: proof of principle DP+Beta	**Objective:** robustness process flow, washing, optimize distillation, upscaling to demo level	**Objective:** use of (hemi-)cellulose and pectin with non-GMO micro-organism to produce sugar → advanced bio-EtOH
Conclusion: positive 100 litre EtOH from 1 ton sugar beets, scale up to Demoplant	**Conclusion (1st part):** higher EtOH yield > 110 litre/ton beet, financing still difficult	**Conclusion:** just start the project
Attention points: robustness process flow, washing beets	**Attention points:** attract financing for Demoplant	**Attention points:** watery substance (residue after distillation = 95% water)
Partners: Acrres, UWM (Poland), VAM Watertech	**Partners:** Acrres, Rodenburg Biopolymers, Licorne Fuels, Sustanable Forum	**Partners:** Acrres, Dutch DNA Biotech

3.4 Betaprocess pilot plant Acrres Lelystad

www.betaprocess.eu

ChemBeet

ERA-NET Bioenergy

3.5 Benchmark Direct Processing

Sugar beet ethanol (via Direct Processing)	Cereal ethanol
Relative simple process / less process steps	More process steps (transfer starch → sugars)
Homogeneous stable sugar%	Unstable input starch and mutation factor
Relative low CAPEX and OPEX	High CAPEX
High ethanol output per HA	Low ethanol output per HA
Positive effect on land use / other crops	Monoculture
Rest streams: high value products	DDGS not stable depending on process

	Sugar beet	Cane sugar	Corn	Cereals
Ethanol yield (HL/HA)	**80 - 85**	**70 - 75**	**40**	**32**
Average water usage (in mm)	**500 - 600**	**900 - 1000**	**600 - 800**	**600 - 1500**

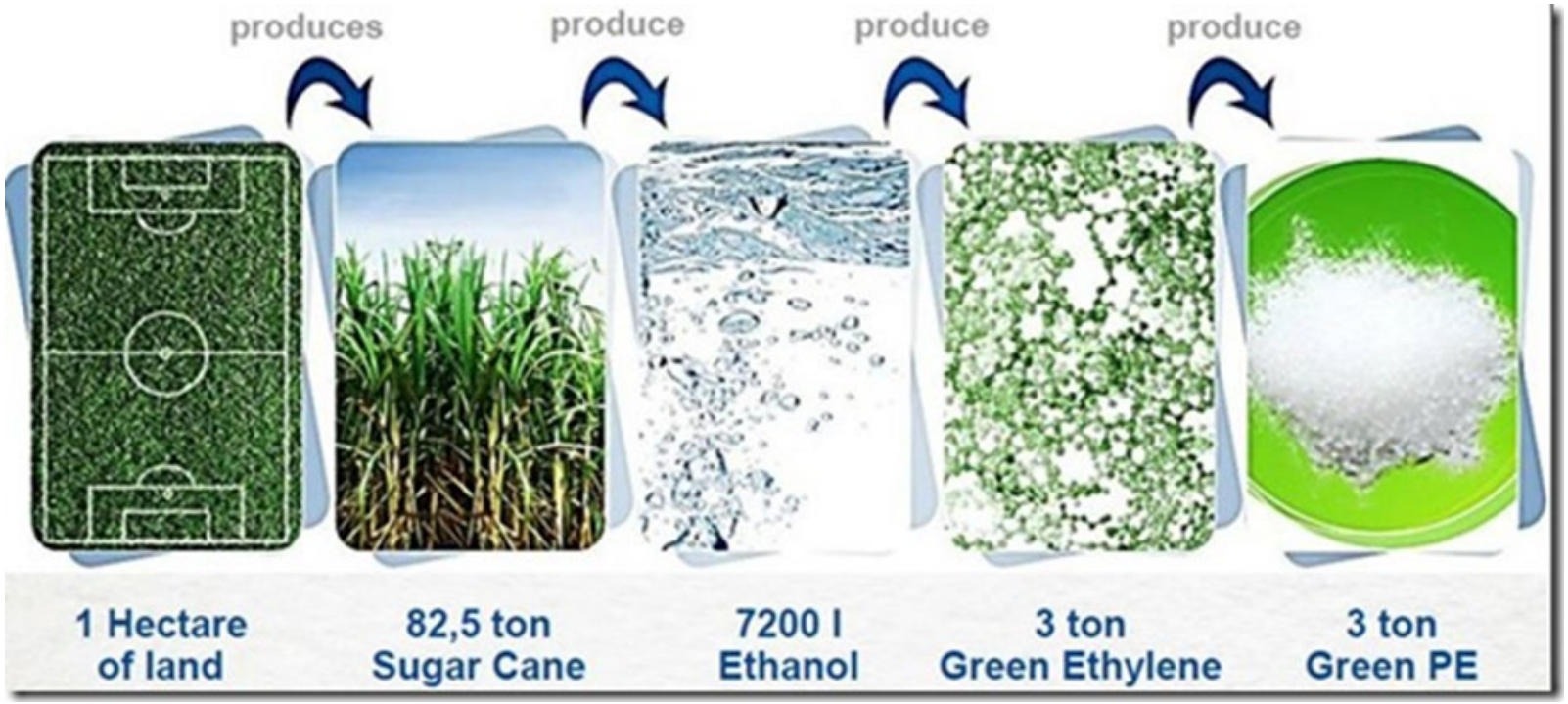
3.6 (preliminary) Results “In Nije DEI”

Batch	1		2		3		4		5		6		gestopt	7		8		9	
Sample	DSD-600-4-1/01		DSD-600-4-1/01		DSD-600-5-1/01		DSD-600-5-1/01		DSD-600-6-1/01		DSD-600-6-1/01		DSD-600-7-1/01	DSD-600-7-1/01		DSD-600-8-1/01		DSD-600-8-1/01	
Run/Reactor	4/R01		4/R02		5/R01		5/R02		6/R01		6/R02		7/R01	7/R02		8/R01		8/R02	
Datum	21-3-2019		21-3-2019		4-4-2019		4-4-2019		23-4-2019		25-4-2019		2-5-2019	2-5-2019		14-5-2019		16-5-2019	
ETHANOL per kg biet totaal productie		4/R01		4/R02		5/R01		5/R02		6/R01		6/R02			7/R02		8/R01		8/R02
KG Biet inzet		529		585		637		637		675		681			754		624		581
KG Ferm massa		620		551		633		693		693		682			716		721		707
Hoeveelheid Suikers	19,0%	100,5	19,0%	111,2	17,5%	111,3	17,5%	111,3	17,9%	121,1	17,5%	119,0		18,6%	140,5	12,7%	79,4	12,7%	73,9
Suiker omzetting factor																			
Theoretisch	0,5383		0,5383		0,5383		0,5383		0,5383		0,5383			0,5383		0,5383		0,5383	
Suiker voor EtOH	90%		90%		90%		90%		90%		90%			90%		90%		90%	
KG EtOH op basis biet (theor)		48,7		53,8		53,9		53,9		58,7		57,7			68,1		38,5		35,8
KG EtOH op basis ferm mass		49,2		50,5		54,3		56,5		70,1		59,9			58,7		50,7		55,1
KG EtOH op basis destillaat		44,5		46,4		48,7		53,8		61,2		60,8			60,1		49,2		49,6
Verschil Dest vs Ferm:		-9%		-8%		-10%		-5%		-13%		1%			2%		-3%		-10%
KG EtOH/TON biet (dest)		**84**		**79**		**76**		**84**		**91**		**89**			**80**		**79**		**85**
LT EtOH/TON biet (dest)		106		100		97		107		115		113			101		100		108

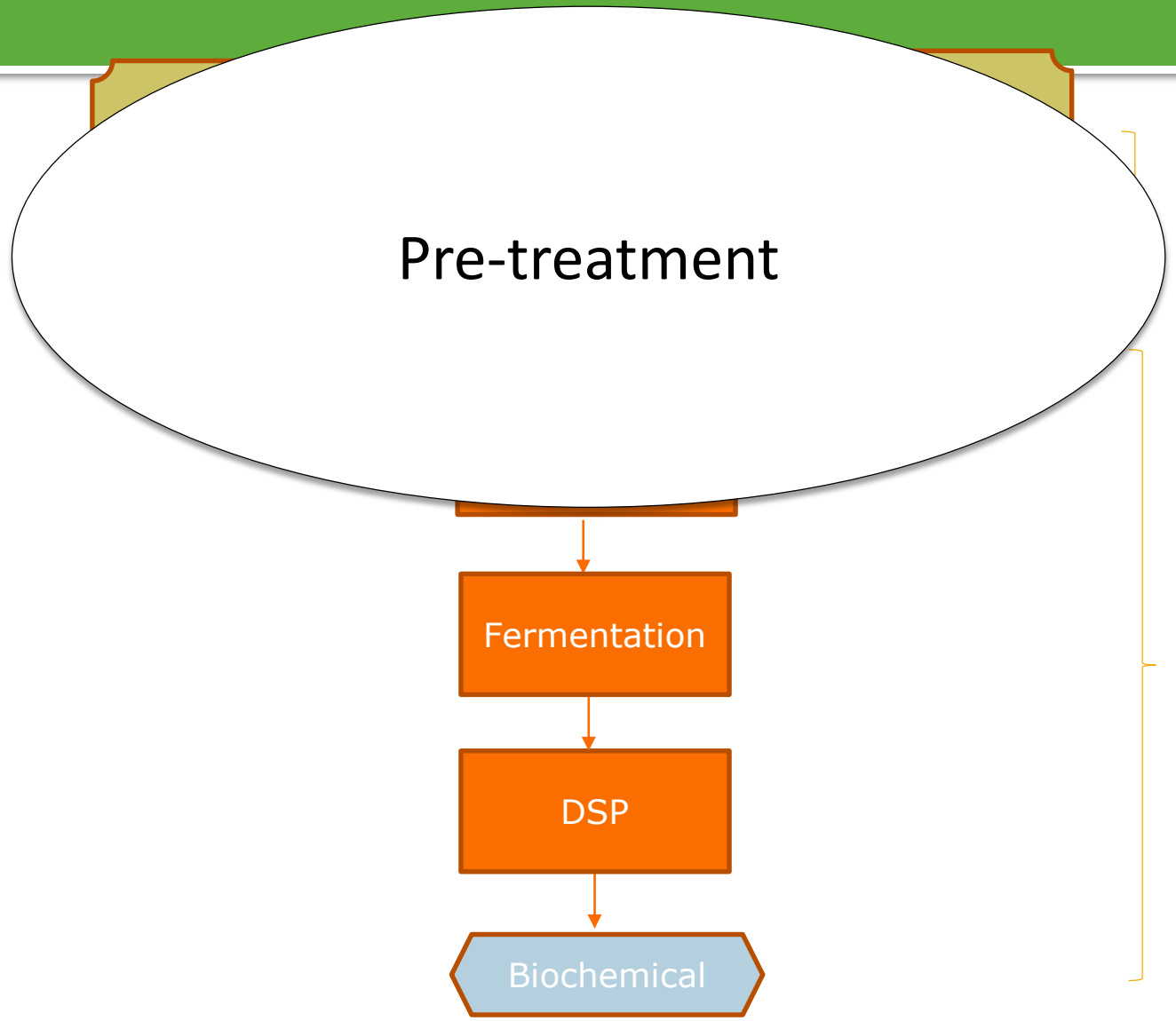
3.7 Ethanol production via DP+Beta

1 HA sugar beet = 8.500 liter ethanol:
→ 20% higher output
1 ton sugar beet = > 100 liter EtOH (Chembeet) in “In NIJE DEI”: > 110 liter

Biethanol: + advanced bioethanol!!



4.0 Pretreatment into fermentable sugars



Multi-feedstock flexibility (at least 200 days sugar beet)

Less process steps

Lower CAPEX

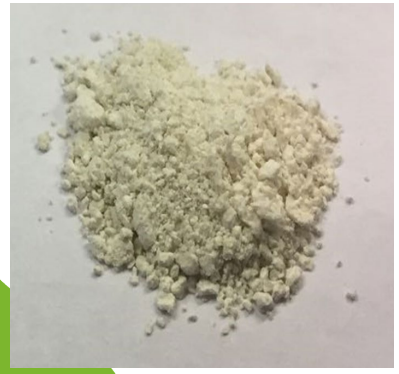
Lower OPEX

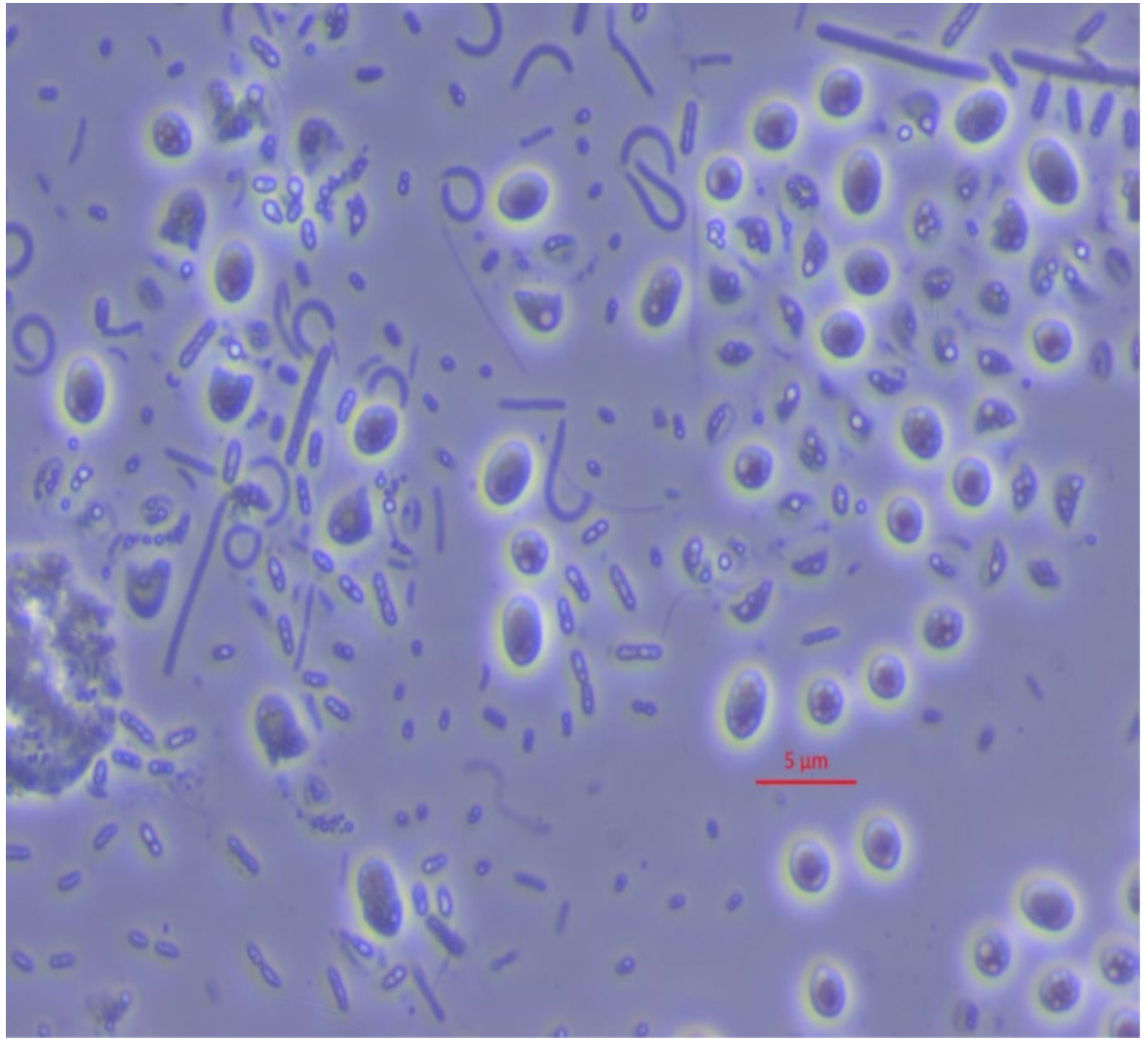
Multi product

4.1 Fermentable sugars: PHA

PHA rich biomass
up to 80% PHA content

Extracted PHA
up to 98% purity





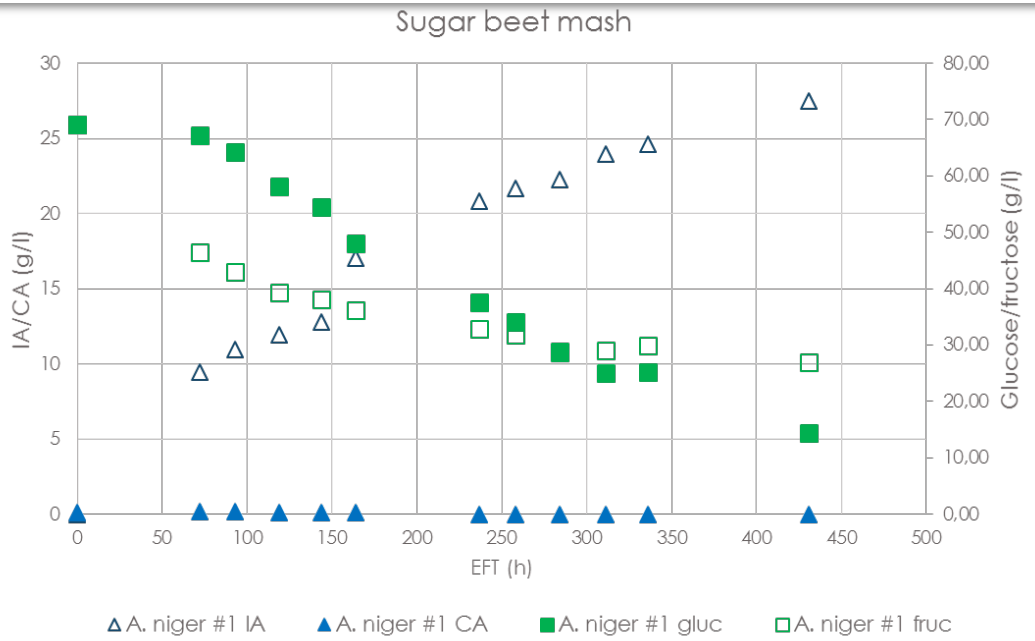
PHA production reactor:

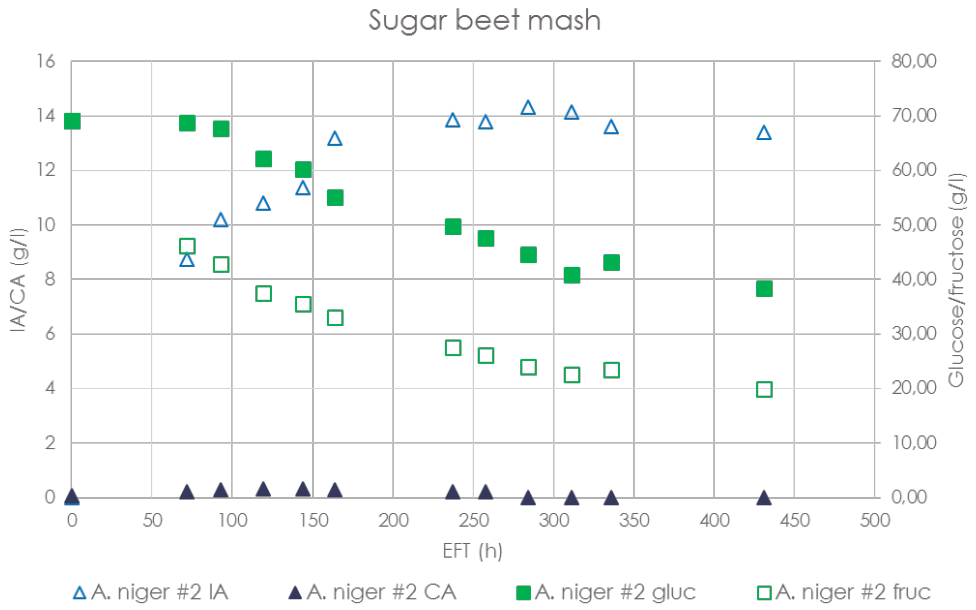
- PHA accumulating microorganisms are starting to grow;
- microbes (orange arrows) that have PHA granules inside;
- nitrogen limited system;
- acetic, butyric and lactic acids are perfect substrates for PHA production.

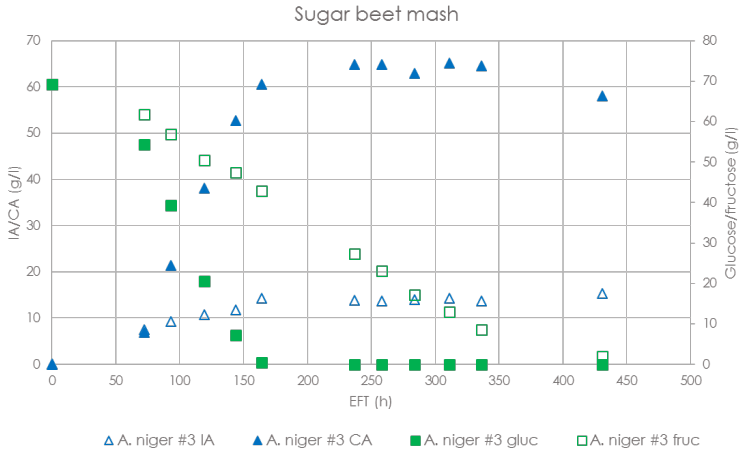
4.2 Fermentable sugars: PHA

Why PHA from sugar? Potential for food packaging!!!!!	**Wastewater**	**Sugar** not suitable for food (as produced by Betaprocess)
Biomass type	Open mixed culture	Open mixed culture
Feedstock cost	Negative cost	Low compared to refined sugar and other biobased feedstocks
Product stability	Dependent on feedstock	Dependent on sugar production process
Legislation	Depending on feedstock waste origin can be an issue	Never considered a waste
Health applications	No	Difficult
Food applications	Difficult and dependent on feedstock	**Yes**

4.3 Fermentable sugars: Itaconic Acid







- Project: “Veni Vidi Veridi”;
- Topsector Energie TEBE117006

4.4 C2 chain potential (Info: IHS Markit 2016)

Product	Ethylene usage		% recycling	Remarks
Polyethylene	11.500	Kton	70%	Largest part in packaging, good recycling (physics and chemical)
Ethylbenzene / styrene / PS	5.000	Kton	20%	Isolation purposes, limited to recycle
Ethylene oxide / ethylene glycol / EO derivate	2.800	Kton	0%	Not to recycle
PP and rubber	1.000	Kton	60%	To recycle
Hexane / Octane	300	Kton	70%	Good to recycle
Others	200	Kton	0%	Not to recycle
TOTAL EU Production	20.800	Kton		Situation 2016, expected yearly growth 4%

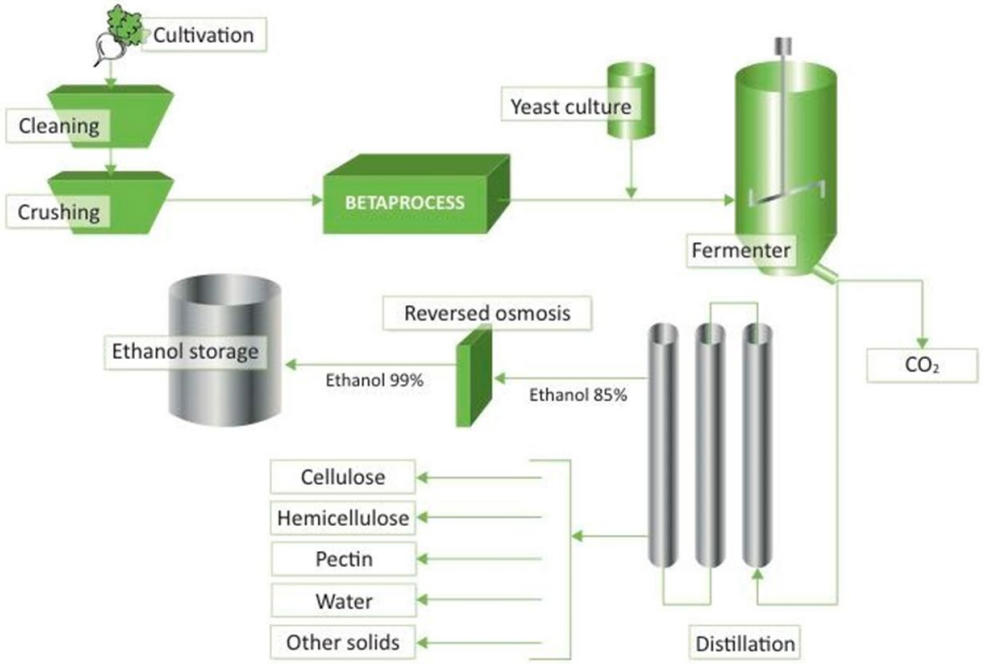
Of which recycled 9.860 kton and
renewed yearly 10.940 kton;

via pyrolysis techniques 2/3 7.100 kton (based on plastics) and
from ethanol 1/3 3.840 kton;

expected growth (< 2030): 6.650 kton.

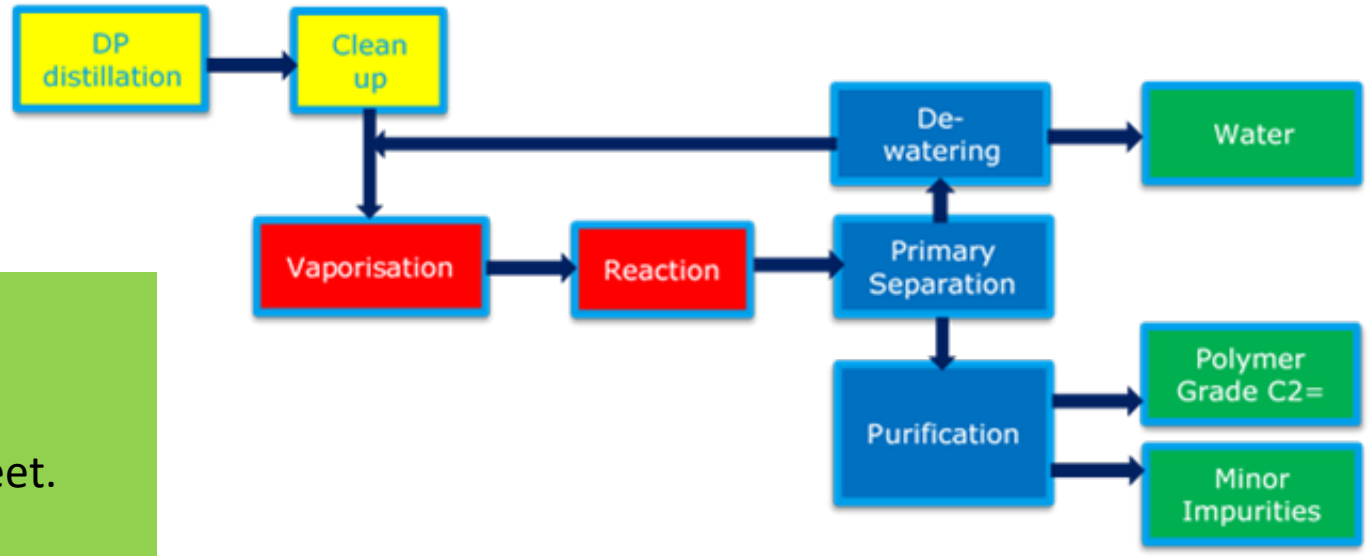
Usage sugar beets:
3,8 mln HA/year =
3% EU arable area

4.5 C2 Chain



Beet cultivation in south east Netherlands (in thousand hectare)			
	1996	2005	2015
Limburg	12,2	9,6	5,2
Oost Brabant	7,2	5,9	3,6
Total	**19,4**	**15,5**	**8,8**

TechnipFMC



Situation in South East of the Netherlands

Potential of 20.000 hectare with 70 ton/hectare means 1.4 million tons of beet.

This is equivalent to 140.000 cubic meter of ethanol (= 110 kta), which could be converted to 64 kta bio ethylene

In cooperation with Technip Benelux BV to combine DP+Beta with the Hummingbird technology

5.1 Conclusions

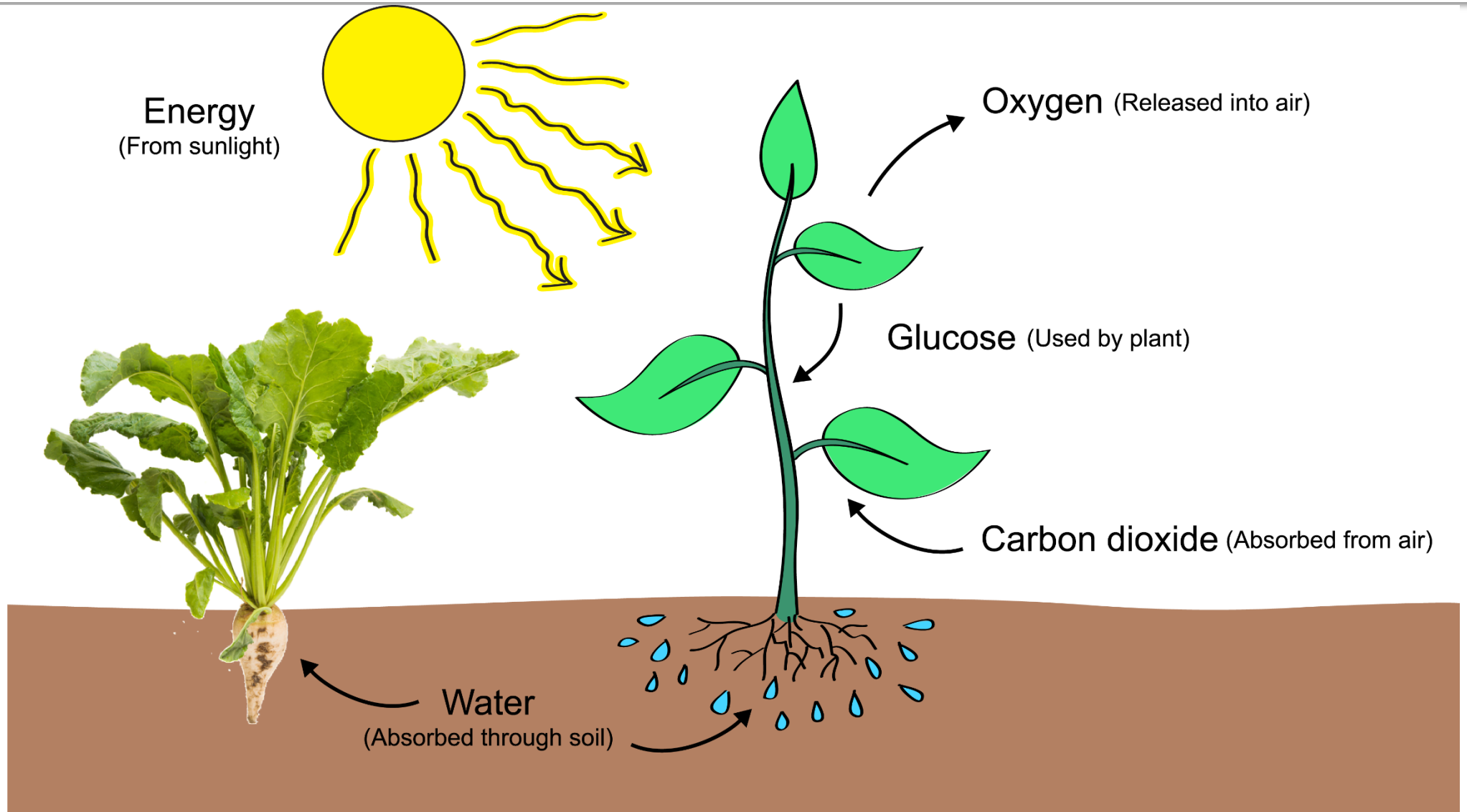
- Direct processing is very attractive (as well for the farmer as the factory);
- Small scale biorefinery is profitable (less transport costs, positive developments rural area);
- Attractive price paid to farmers (net – income);
- Important for rural development, green future, green chemistry;
- Not only for ethanol but also for other green chemicals (future);
- Soil fertility, water usage, yielding other crops, sustainability → all in favour of sugar beets;
- For realisation of objectives Paris Agreement (COP21) you need sugar beet!!

5.2 Conclusions – Yield and ratio added value

n-Butanol	0.05	kg but /kg sugar beet
	2.73	**€ revenue butanol/€ sugar beet cost**
Succinic Acid	0.13	kg SA/kg sugar beet
	11.4	**€ revenue SA/€ sugar beet cost**
Lactic Acid	0.15	kg LA/kg sugar beet
	6.32	**€ revenue LA/€ sugar beet cost**
Fuel Ethanol	0.09	kg EtOH/kg sugar beet
	1.60	**€ revenue EtOH/€ sugar beet cost**
Food Ethanol	0.09	kg EtOH/kg sugar beet
	2.56	**€ revenue EtOH/€ sugar beet cost**

- Ratio added value: selling price of produced product divided by purchase price of feedstock (info: TU Delft, A. Straathof, 2017)

5.3 Sugar beet and a sunny future!!!!!



Direct Processing with Betaprocess

Contact

DSD Betaprocess

Choorhoekseweg 8-b
NL 4424 NW Wemeldinge
The Netherlands
T +31 (0)113 62 10 74
W www.betaprocess.eu

Hans van Klink
Director Project Development
E hans@dsdbv.com
M +31 (0)6 53 40 47 21

Cees van Loon
Commercial manager
E cees@betaprocess.eu
M +31 (0)6 44 92 07 08

Chris de Visser
Business Development ACRRES
E chris.devisser@wur.nl
M +31 (0)320 291 692

Carel Braakman
Project advisor
E carel@zeelandnet.nl
M +31 (0)6 53 25 40 92