Nationaler Workshop Biotreibstoffe
Wien, 29. September 2016

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VOGELBUSCH Biocommodities GmbH

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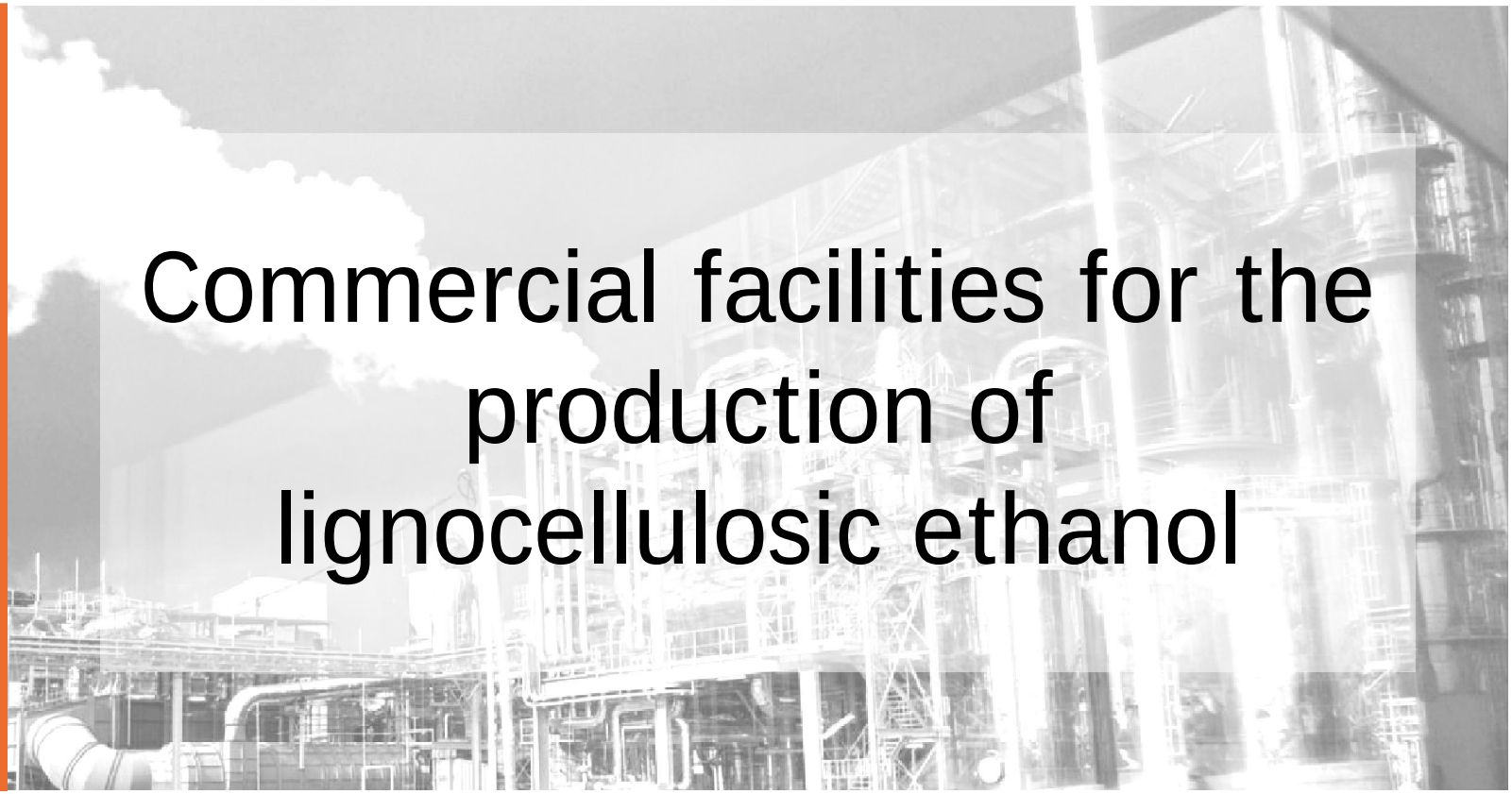
we make biotechnology work

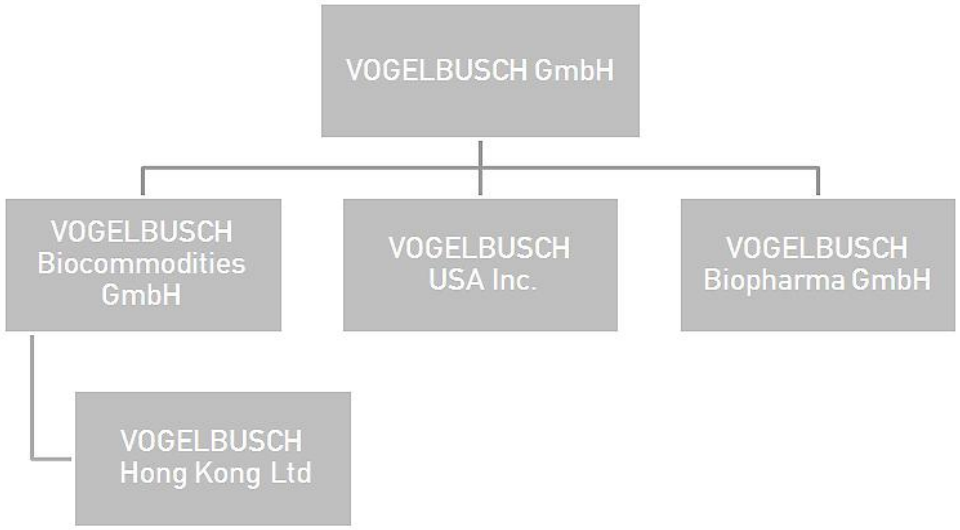


Commercial facilities for the production of lignocellulosic ethanol

VOGELBUSCH group

| The bioprocess company

- since 1921
- independent
- staff of 140
- inhouse R&D laboratories
- globally active
- branch offices in USA and Hong Kong
- serving the starch, sugar & pharmaceutical industry



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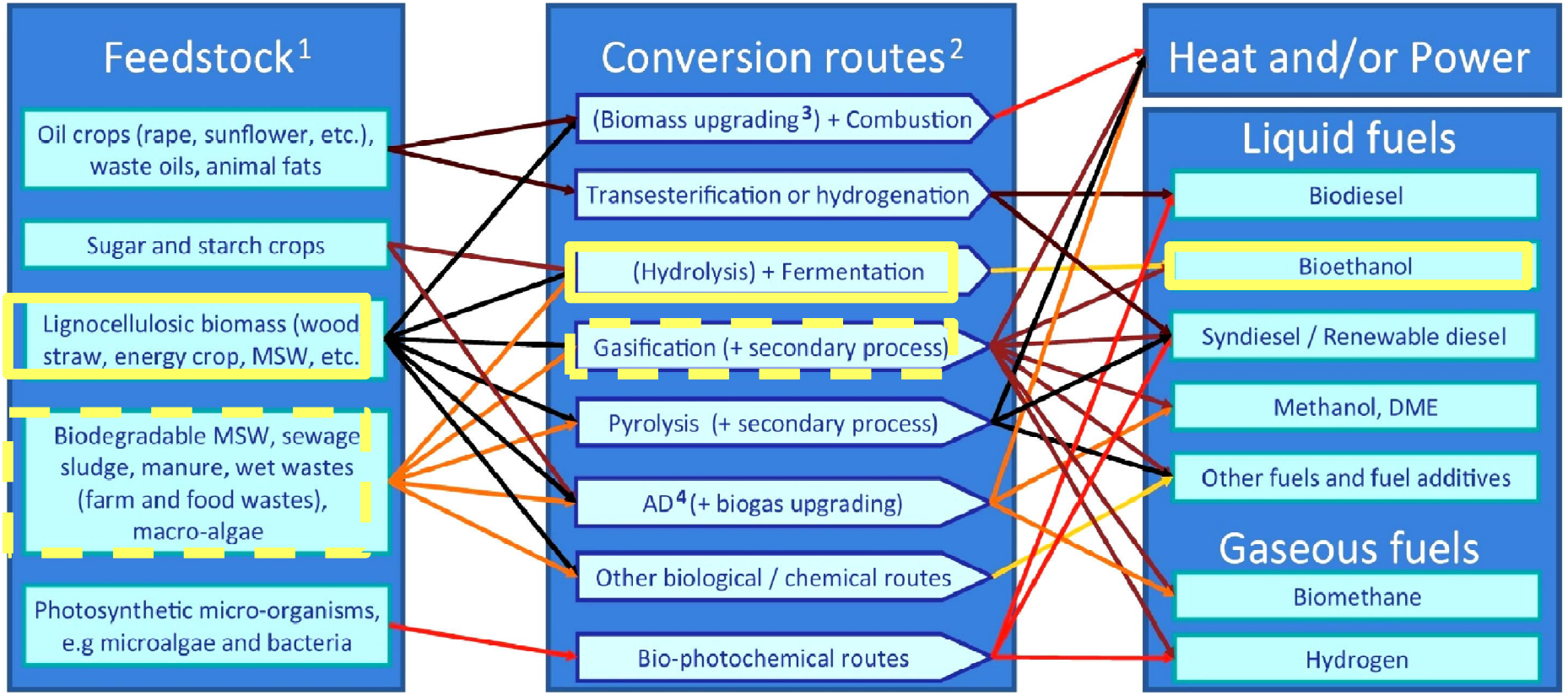
Biorefineries



[1] Parts of each feedstock, e.g. crop residues, could also be used in other routes

[2] Each route also gives co-products

[3] Biomass upgrading includes any one of the densification processes (pelletisation, pyrolysis, torrefaction, etc.)

[4] AD = Anaerobic Digestion

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Source: Executive Summary Bioenergy – a Sustainable and Reliable Energy Source, IEA, 2009

From 1st to 2nd Generation

Mechan . treatment → Hydro-thermal treatment → Enzym. hydrolysis → Fermen-tation → Distillation Dehydrat.. → Residues concentr. & drying

Modified 1G technology

Mechan. treatment → Hydro-thermal treatment → Enzym. hydrolysis → Fermen-tation → Distillation Dehydrat. → Residues concentr. Lignin drying

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SHOWCASE PROJECT: INBICON | Kalundborg | Denmark

Second generation demonstration plant

Input:	30 000 t/y wheat straw
Output:	5.4 million liters ethanol
	13,100 t lignin pellets
	11,250 t C5-molasses

SHOWCASE PROJECT: INBICON | Kalundborg | Denmark

Combination of technology

Straw Handling	Hydro-thermal Pre-treatment	Liquefaction	Fermentation	Distillation
				
DONG 20 years experience	INBICON core technology		VOGELBUSCH downstream technology	

Inbicon

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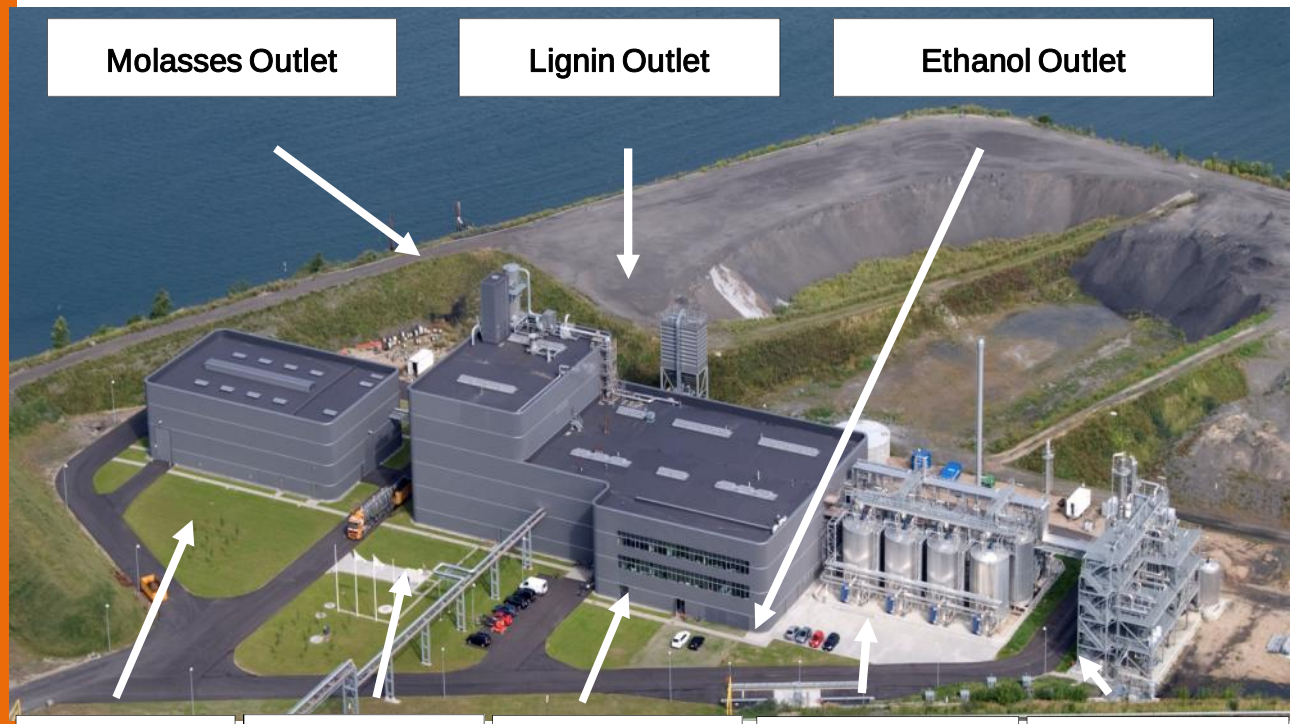
Strong collaboration for successful 2G ethanol journey

SHOWCASE PROJECT: INBICON | Kalundborg | Denmark



Certified suppliers – flexible choice

Enzyme

novozymes · DUPONT · DSM

Yeast

novozymes · LESAFFRE GROUP · DSM · ERRANOL

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Only high value products

Advanced Bioethanol

2G bioethanol replacing gasoline

Lignin

Extraordinary high quality lignin e.g. solid biofuel replacing coal

Vinasse

Vinasse as booster to biogas and leftover as fertilizer

Inbicon

Varieties of biomass feedstock tested

SHOWCASE PROJECT: INBICON | Kalundborg | Denmark

Status Quo

- Proven technology for integral process on industrial scale – design capacity reached
- Flexible biomass source
- One-step steam pre-treatment
  – no acid or base
  – no steam explosion
- 2G Bioethanol produced at spec
- Distribution of BIO95 2G fuel in Denmark by STATOIL
- Design available for industrial scale plants
  – total performance warranties
- Technology 100% owned by DONG Energy – leading European renewable energy group

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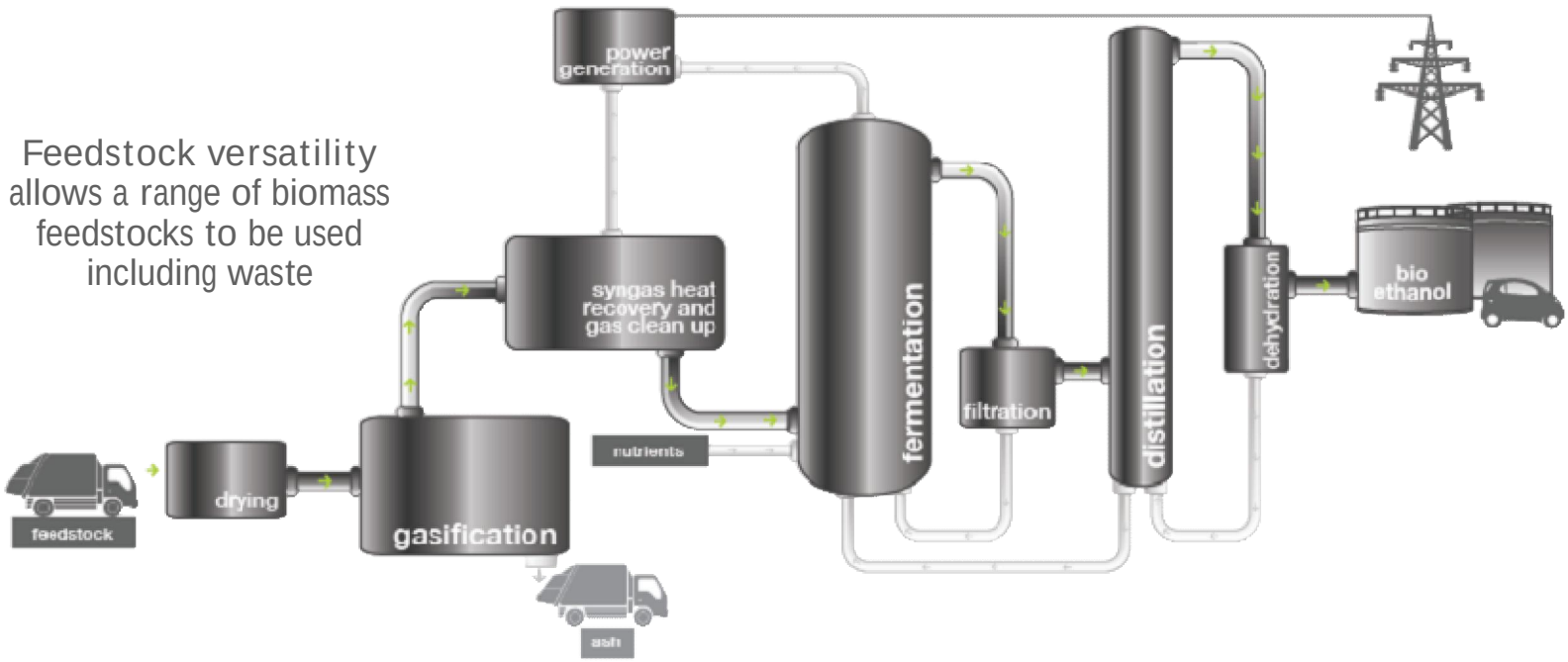
Inbicon

SHOWCASE PROJECT: INEOS Bio | Vero Beach, FL | USA

Process Overview: Bioethanol from waste combined with CHP

Waste heat and offgas recovery for renewable power generation for use in the bioethanol process and for export

Feedstock versatility allows a range of biomass feedstocks to be used including waste



Two stage gasification to produce syngas without significant by-products

Syngas converted into bioethanol via fermentation using proprietary biocatalyst then distillation

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INEOS Bio

Syngas fermentation (1)

General facts

- Fermentation of syngas into ethanol based on the following reactions:
  - $6CO + 3H_20$ à $C_2H_5OH + 4CO_2$
  - $2CO_2 + 6H_2$ à $C_2H_5OH + 3H_20$
- Also other side reactions e.g. into acetic acid
- Microorganisms:
  - High productivity of ethanol
  - Low by-product formation
  - High tolerance against inhibiting substances in the syngas
  - e.g. Clostridium ljungdahlii

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Syngas fermentation (2)

General facts

- Feedstock for syngas fermentation can be derived from a broad range of sources:
  - Syngas of biomass
    (e.g. vegetative waste, yard waste)
  - Syngas of municipial wastes
  - Industrial waste gases
    (e.g. steel production – Arcelor Mittal)
  - Combination of several sources
- Waste streams converted directly on site into thermal or electric power

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SHOWCASE PROJECT: INEOS Bio | Vero Beach, FL | USA

Second generation commercial plant

Input:	vegetative waste yard waste municipal solid waste
Output:	30 million liters ethanol per year 6 MW gross electric power generation

SHOWCASE PROJECT: INEOS Bio | Vero Beach, FL | USA

Status quo

- Strong US government partnership
  - DOE grant & USDA loan guarantee
- EPC awarded to AMEC in November 2010
- Commissioned in 2013
- Technology upgrades in 2014
- No confirmed ethanol production
- Meanwhile INEOS announced to sell the plant

INEOS Bio

Comparison of different technologies

	Starch based	Cellulosic based	Syngas fermentation
Raw material	wheat / corn	wheat straw	biomass
Yield l alcohol / t raw material	390	200 - 280	200 - 260
Fermentation time hours	60 – 70	150 – 200	< 1
Alcohol content %vol in mash	11 – 16	7 - 10	3 – 6
Viscosity cP	30 – 50	100 - 200	1 - 5
Steam consumption t /1000 l alc			
Upstream (Hydrolysis)	0.3 – 0.4	2.0 – 4.0	-
Distillation / Dehydration	1.2 – 2.0	1.4 – 2.5	1.8 – 4.5
Evaporation / Drying	1.8 – 2.0	2.5 – 4.0	???
By products	DDGS	lignin C5 fraction à thermal / electrical power	thermal / electrical power

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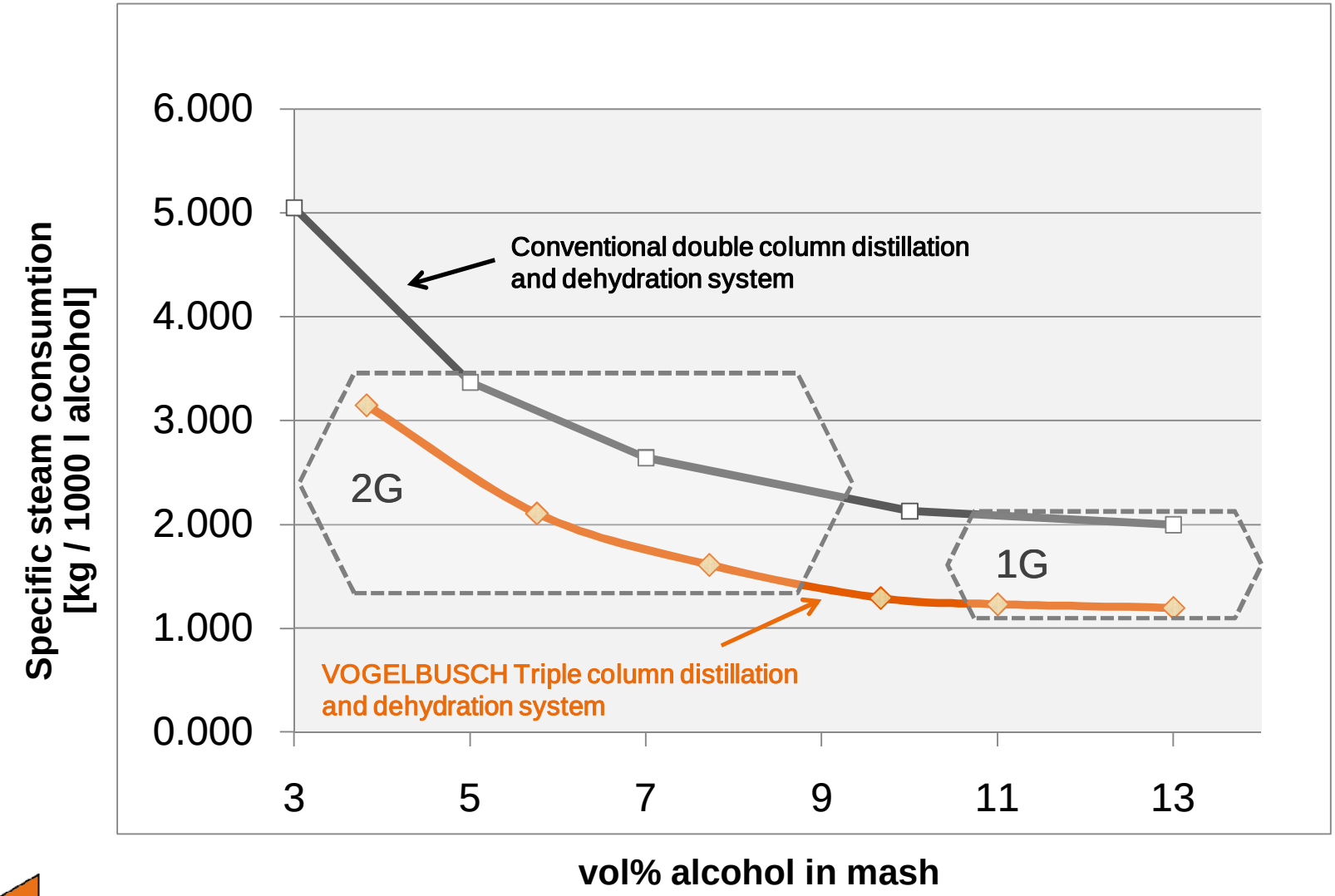
Influence of alcohol content in mash on steam demand

| Vogelbusch Multipressure distillation



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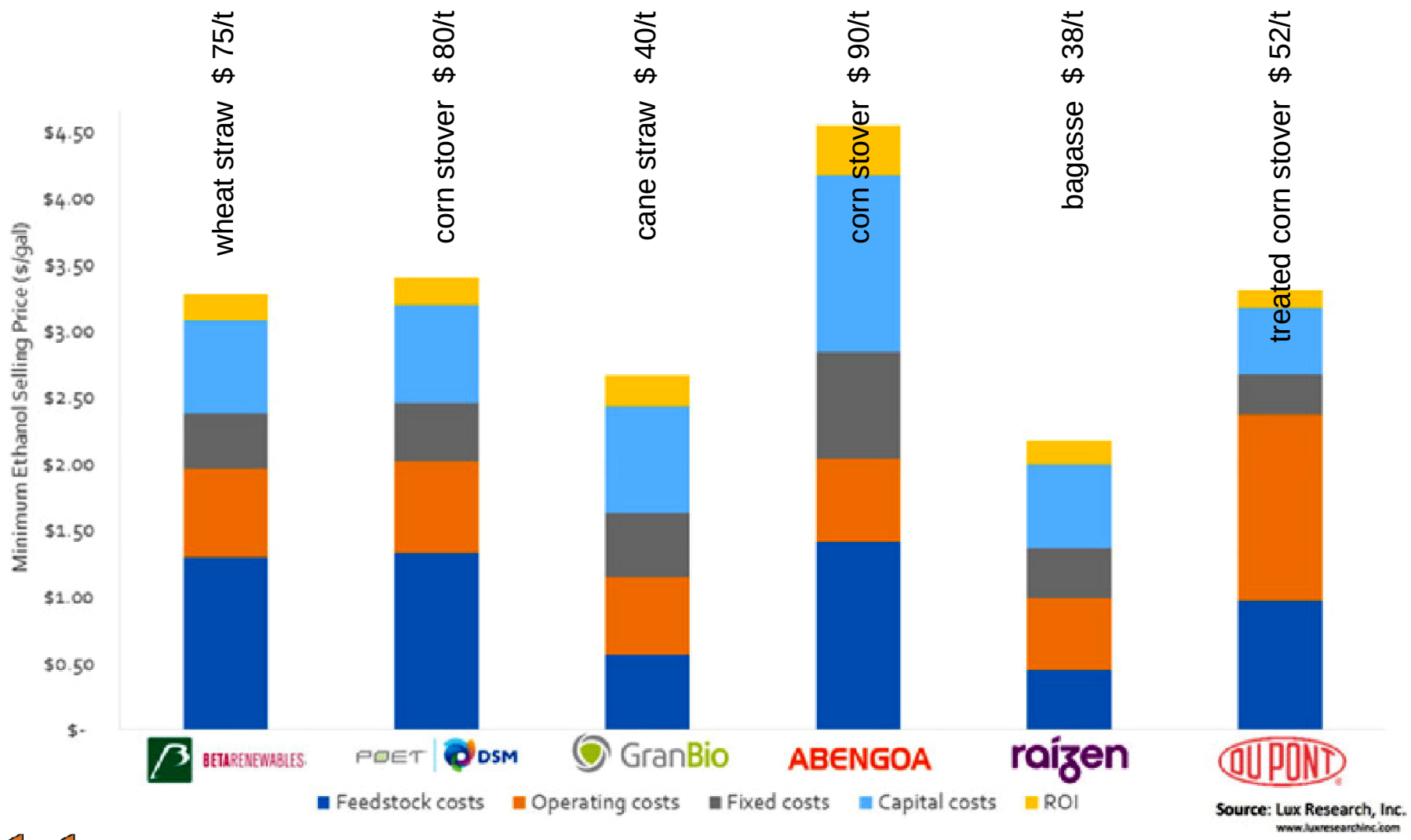
Selected examples of industrial scale 2G ethanol plants

| Status Quo (1)

Name	Place	Capacity (million l/y)	Investment (million)	Start-up
Inbicon	Kalundborg, DK	5.4	68 EUR	2010
Ineos Bio	Vero Beach, FL	30	130 USD	2013
Beta Renewables (Proesa)	Crescentino, IT	76	140 EUR	2013
POET-DSM	Emmetsburg, IO	95	275 USD	2014
Abengoa	Hugoton, KS	95	504 USD	2014
Raizen (Iogen)	Piracicaba, BR	38	230 BRL	2014
GranBio (Proesa)	Alagoas, BR	82	455 BRL	2014
Enerkem	Edmonton, AL	38	200 CAD	2014
DuPont	Nevada, IO	114	275 USD	2015
ArcelorMittal (LanzaTech)	Ghent, NL	60	87 EUR	(2017)

Projected cellulosic ethanol production costs

| Status Quo (2)



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Cellulosic ethanol

| Status Quo (3)

ACHIEVED

- Stable, proven processes
- Plants in industrial design online
- Industrial product quality requirements
- Additional income due to valuable byproducts

UNRESOLVED

- Insufficient legal framework to back up G2 ethanol investments
- High investment costs compared to G1 plants
- Raw material availablity, logistics and costs
- Production costs
- „First of its kind“ issues

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Thank you for your attention.

Questions?
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