Fachgespräch Bioenergieforschung
Wien, 18. März 2016

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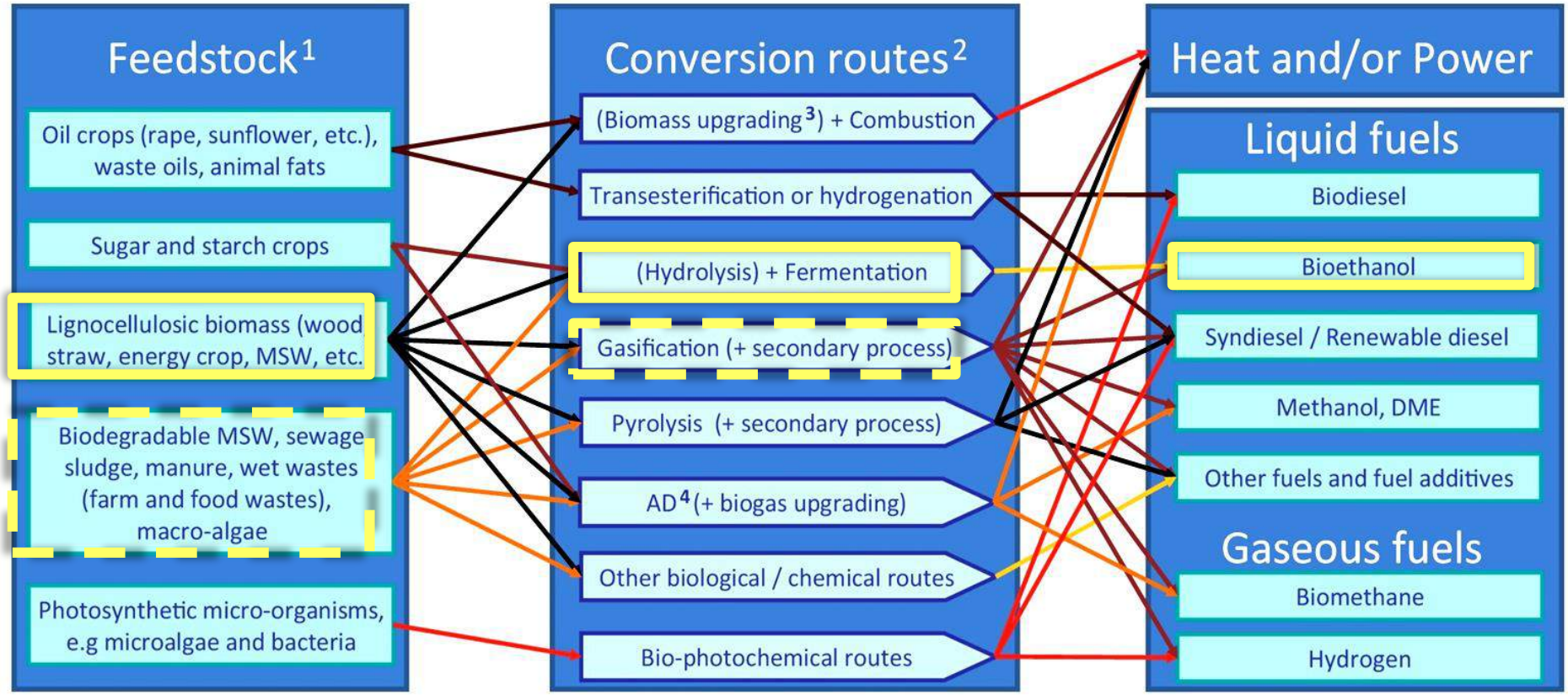
Industrielle Anlagen zur Produktion von Bioethanol aus lignozellulosehältigen Rohstoffen

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

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

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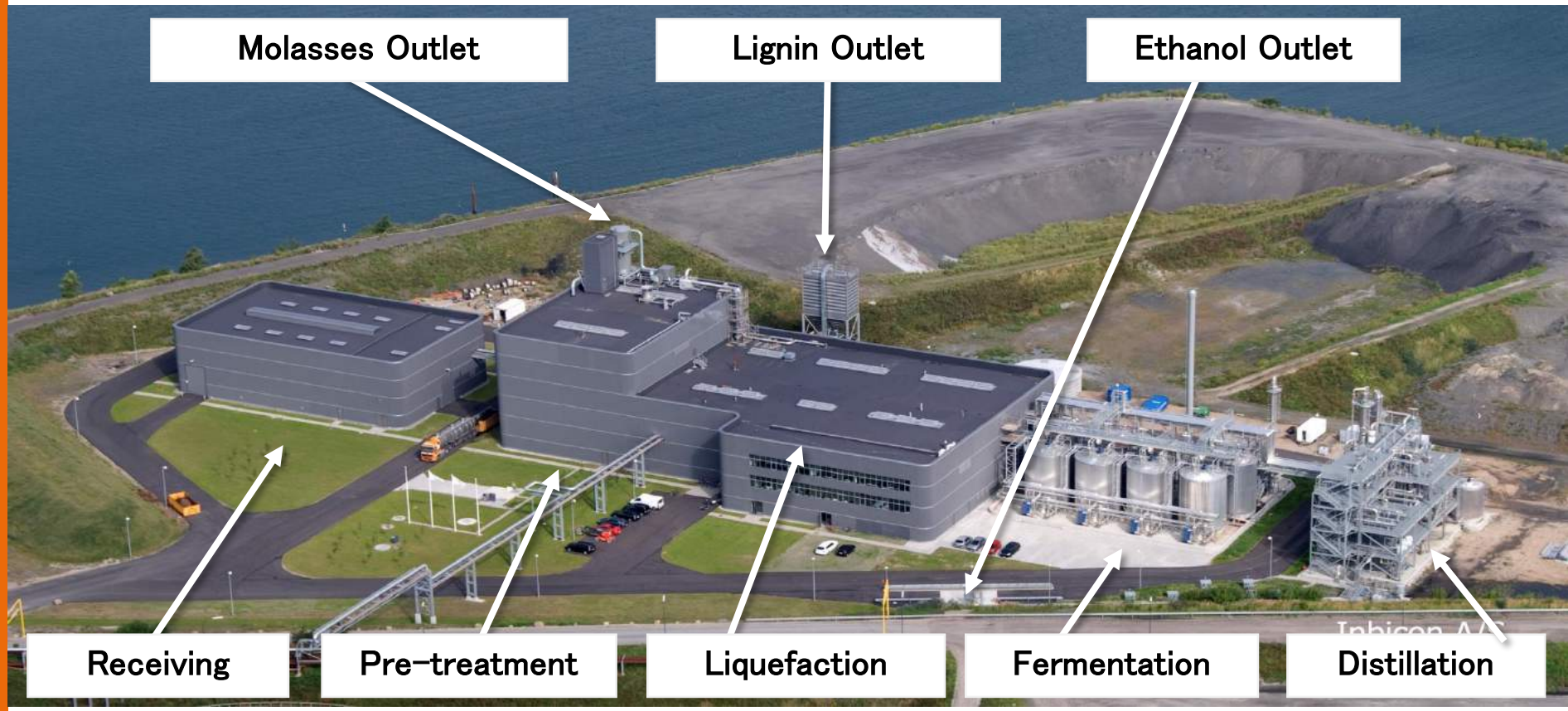
SHOWCASE PROJECT: INBICON | Kalundborg | Denmark

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



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Inbicon

SHOWCASE PROJECT: INBICON | Kalundborg | Denmark

Status Quo

- Started-up in 2010
- Proven technology for integral process on industrial scale
- 2G Bioethanol produced at spec
- Plant mothballed in 2015

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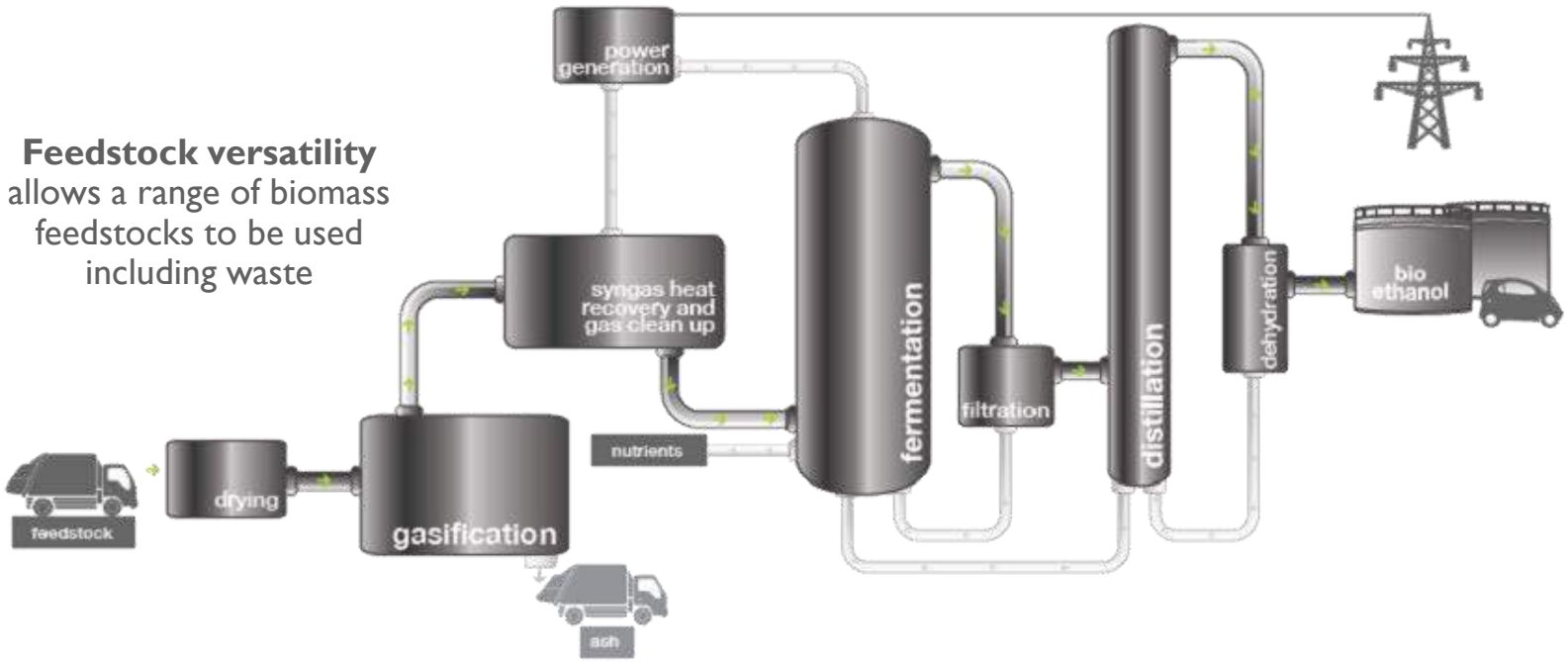
Inbicon

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:
  - $6CO + 3H_20 \rightarrow C_2H_5OH + 4CO_2$
  - $2CO_2 + 6H_2 \rightarrow C_2H_5OH + 3H_20$
- 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

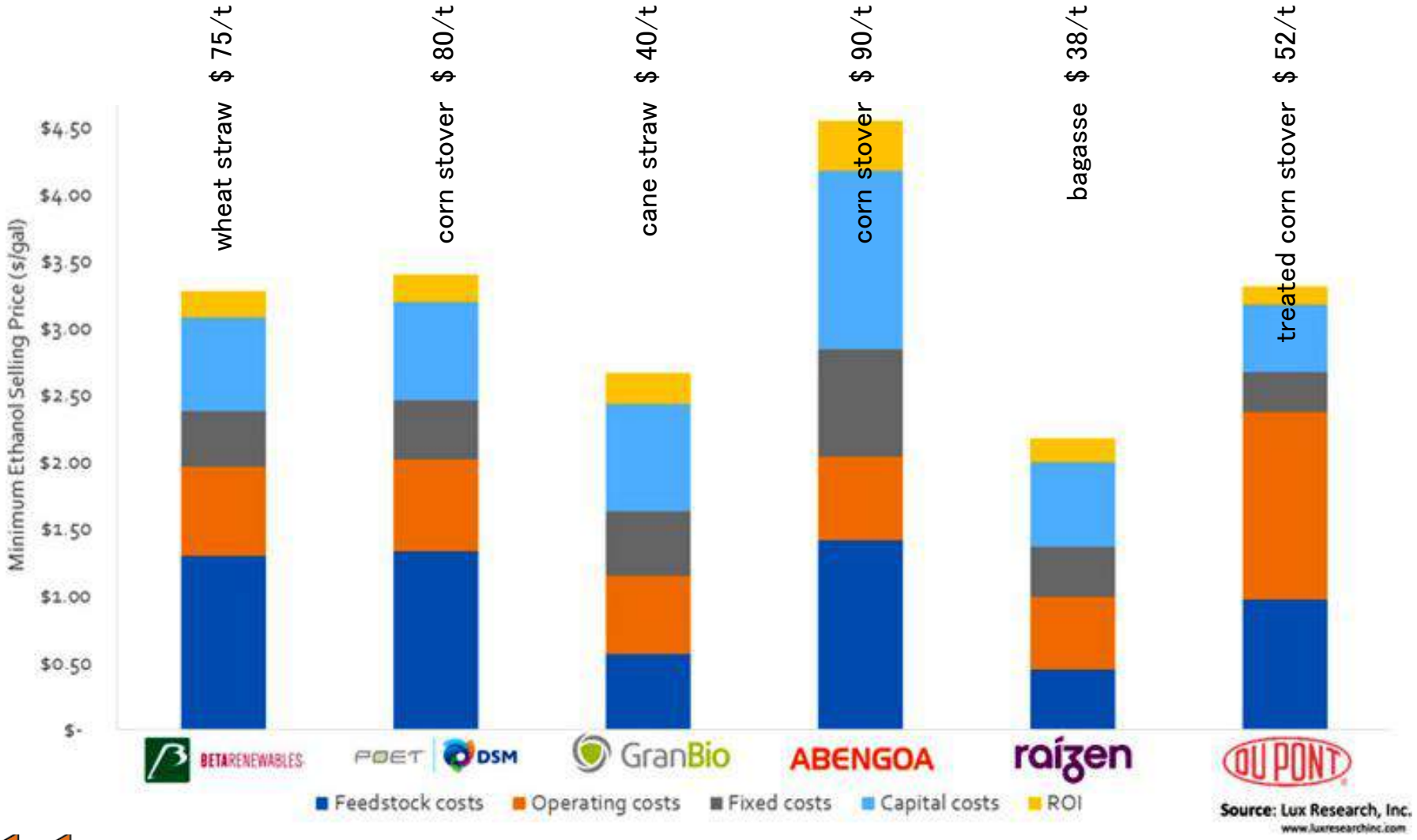
Current examples of industrial scale 2G ethanol plants

| 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

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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Danke für Ihre Aufmerksamkeit.

Fragen?
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