

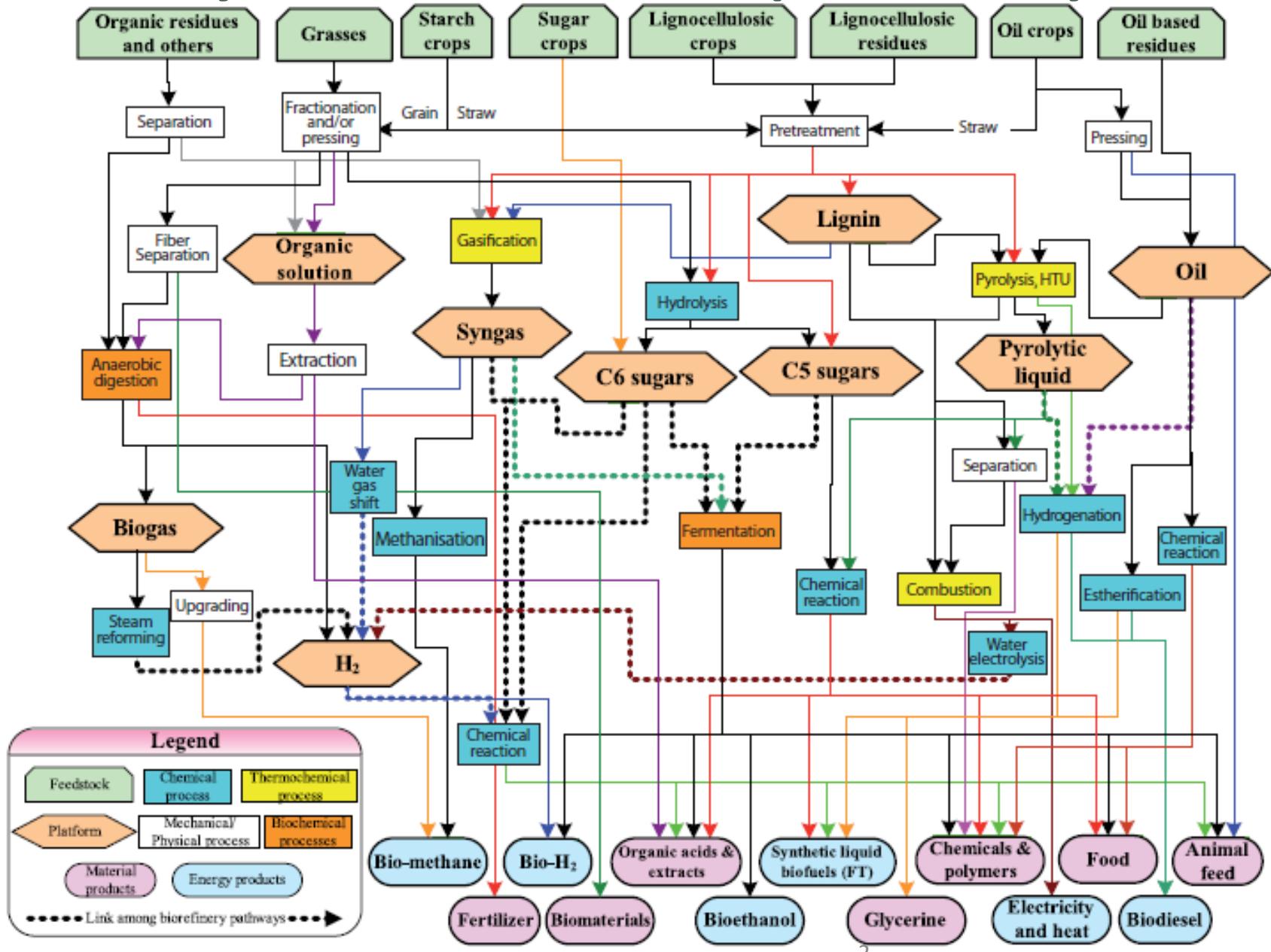
# Biorefineries in Europe (and World)

**Francisco Gírio**

*Head of Bioenergy Unit*

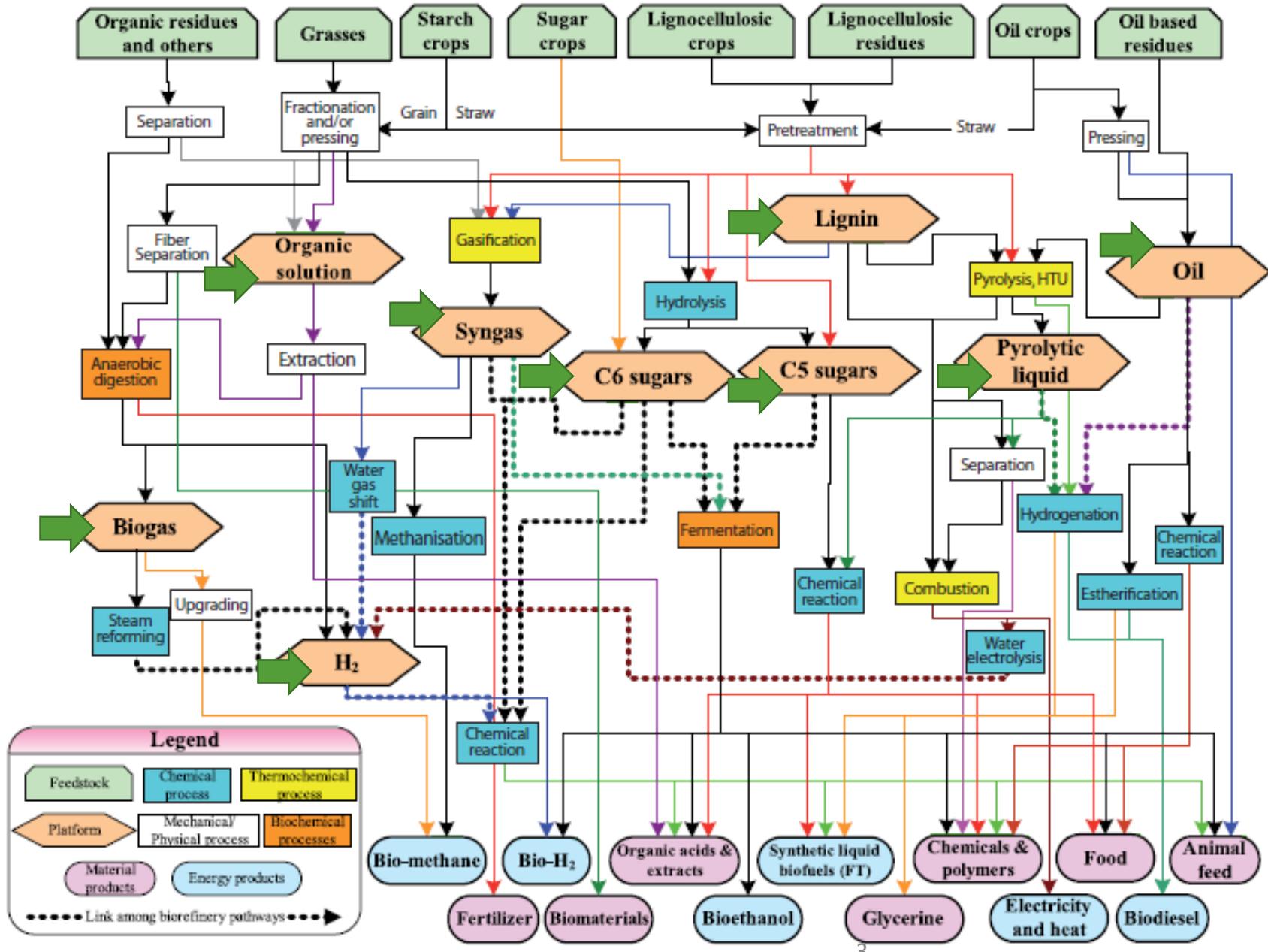
*LNEG - Laboratório Nacional de Energia e Geologia  
Lisboa, Portugal*

# Biorefinery for Biofuels: A Complex Factory?

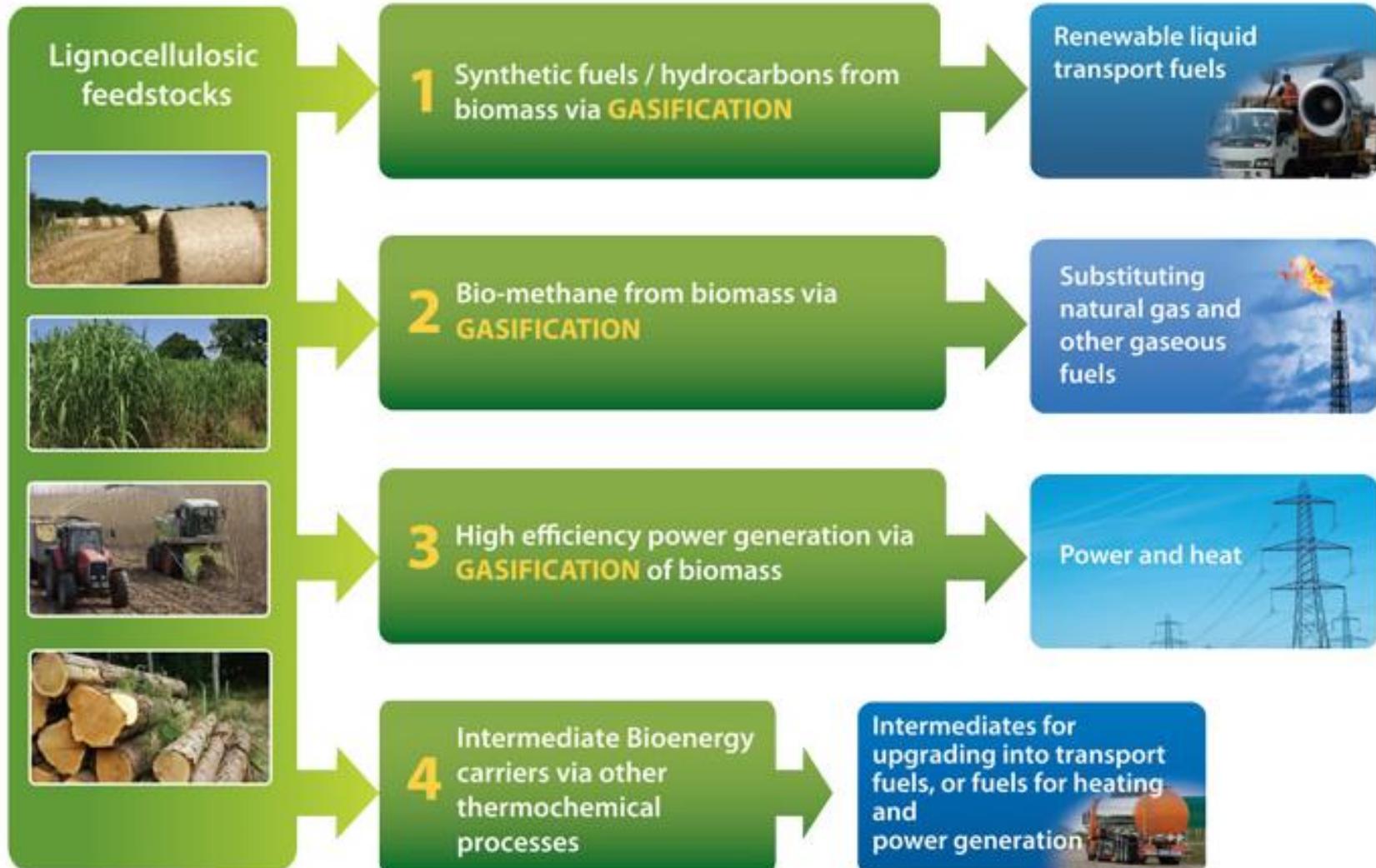


Source: IEA Bioenergy: Task 42- Biorefineries

# Several Platforms and Multi-Products



# Thermochemical & chemical conversion value chains



# Power and heat at high efficiency

SE

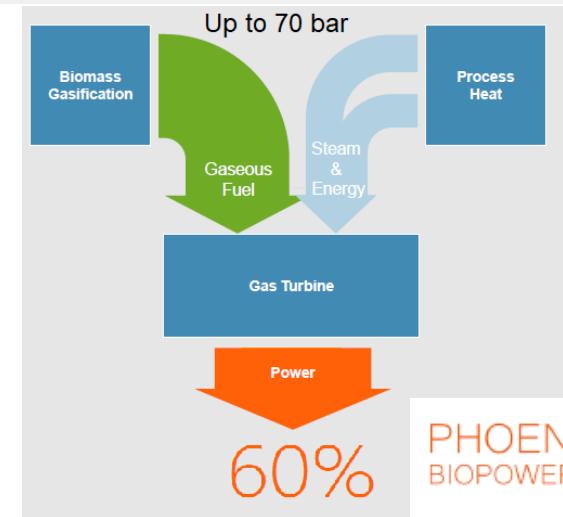
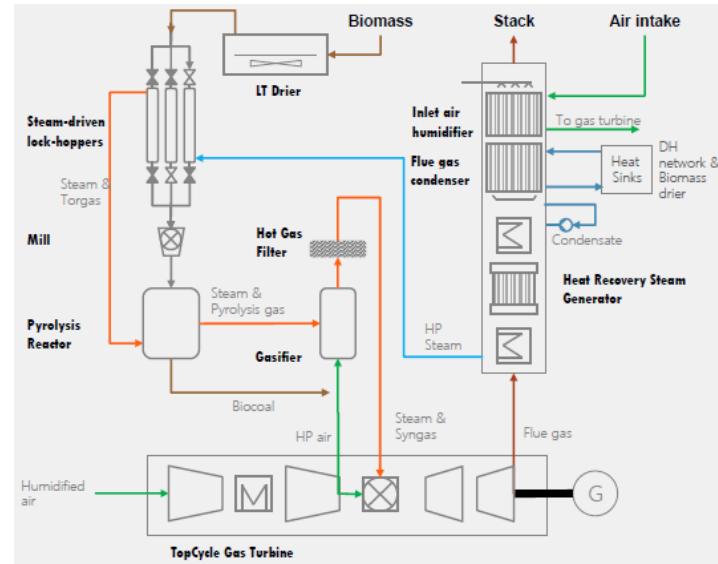
Photo Holger.Ellgaard - Eget arbete



2016 KVV8 – Värtaverket

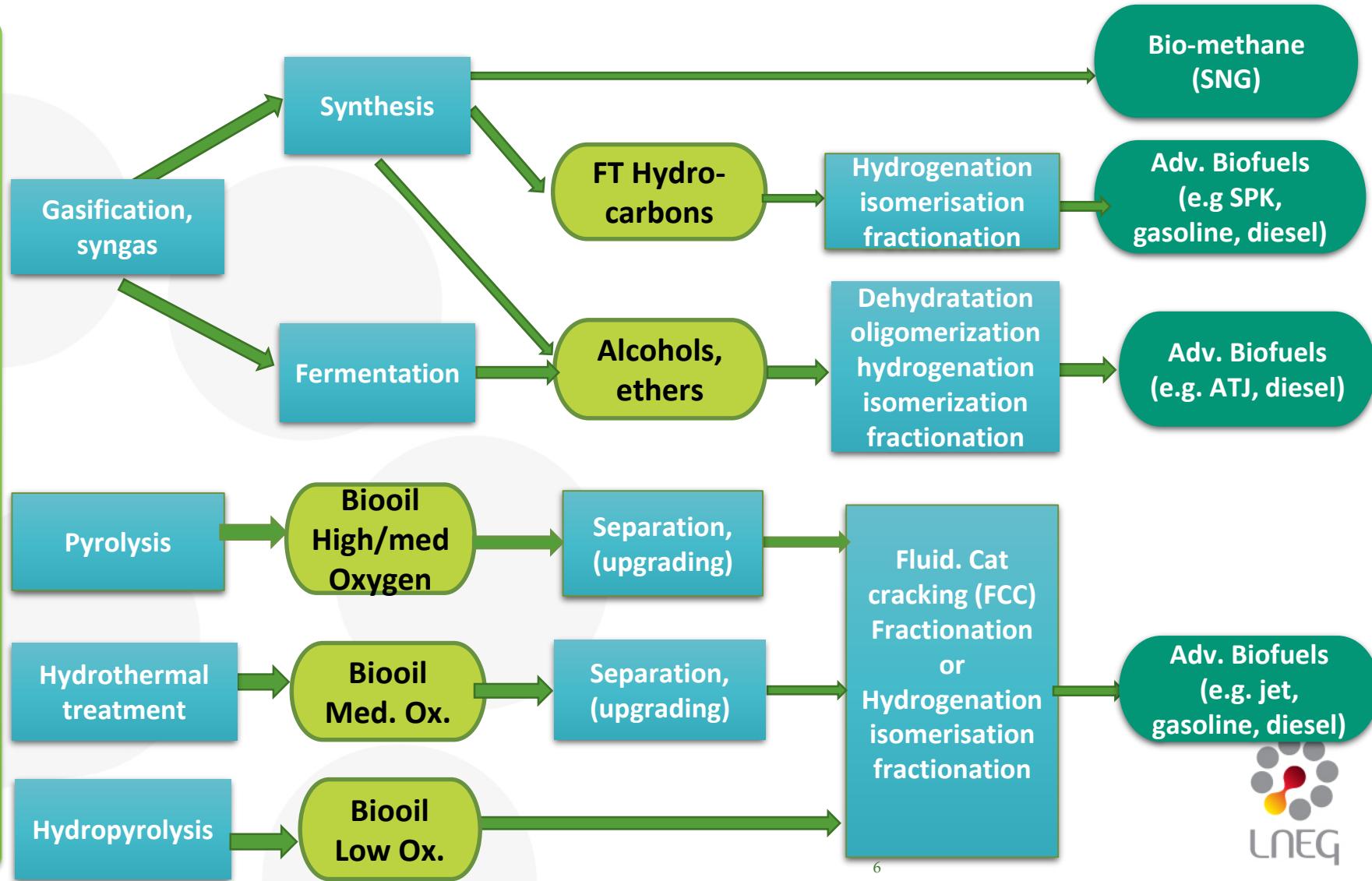
345 MW CFB Steam 140 Bar/560°C

130 MW power gross, 200 MW heat + 80 MW from FG condensing. >100 % efficiency (LHV).  
500 M€ investment. Boiler supply by Andritz



# Intermediates to hydrocarbons

LC BIOMASS



# Thermal gasification to biofuels

Developer/project		Feed	Year	Cap. MWth	Type	Status
Ambigo	NL	LC Biomass		4	SNG	Demo
Bioliq	DE	PO+char	2013	5	feed	Demo
BioTFuel	DE/FR	Torr. ag. resid.	2017	15	feed	Demo
Enerkem	CA	RDF	2014	30	EtOH	1 <sup>st</sup> ind.
	NL	Plastic waste		220	MeOH	Comm.
EON Bio2G	SE	LC biomass		200	SNG	1 <sup>st</sup> ind.
Fulcrum	USA	RDF		50	BTL	1 <sup>st</sup> ind.
Gobigas	SE	LC biomass	2013	20	SNG	1 <sup>st</sup> ind.
GoGreenGas	UK	RDF	2018	4	SNG	Demo
GTI	USA+	LC biomass	2009	2	BTL	Demo
Kaidi Ajos	FI/CN	LC biomass		300	BTL	1 <sup>st</sup> ind.
LTU Green Fuels	SE	Black liquor, PO	2009	1	DME	Demo
Red Rock	USA	LC biomass		75	BTL	1 <sup>st</sup> ind.
Sekisui/Lanzatech	JP/NZ	MSW	2013		EtOH	Pilot
						†2017

# Thermal gasification to biofuels

Developer/project		Feed	Year	Cap. MWth	Type	Status
Ambigo	NL	LC Biomass		4	SNG	Demo
Bioliq	DE	PO+char	2013	5	feed	Demo
BioTFuel	DE/FR	Torr. ag. resid.	2017	15	feed	Demo
Enerkem	CA	RDF	2014	30	EtOH	1 <sup>st</sup> ind.
	NL	Plastic waste		220	MeOH	Comm.
EON Bio2G	SE	LC biomass		200	SNG	1 <sup>st</sup> ind.
Fulcrum	USA	RDF		50	BTL	1 <sup>st</sup> ind.
Gobigas	SE	LC biomass	2013	20	SNG	1 <sup>st</sup> ind.
GoGreenGas	UK	RDF	2018	4	SNG	Demo
GTI	USA+	LC biomass	2009	2	BTL	Demo
Kaidi Ajos	FI/CN	LC biomass		300	BTL	1 <sup>st</sup> ind.
LTU Green Fuels	SE	Black liquor, PO	2009	1	DME	Demo
Red Rock	USA	LC biomass		75	BTL	1 <sup>st</sup> ind.
Sekisui/Lanzatech	JP/NZ	MSW	2013		EtOH	Pilot
						†2017

# Operating gasification to biofuel plants

SE

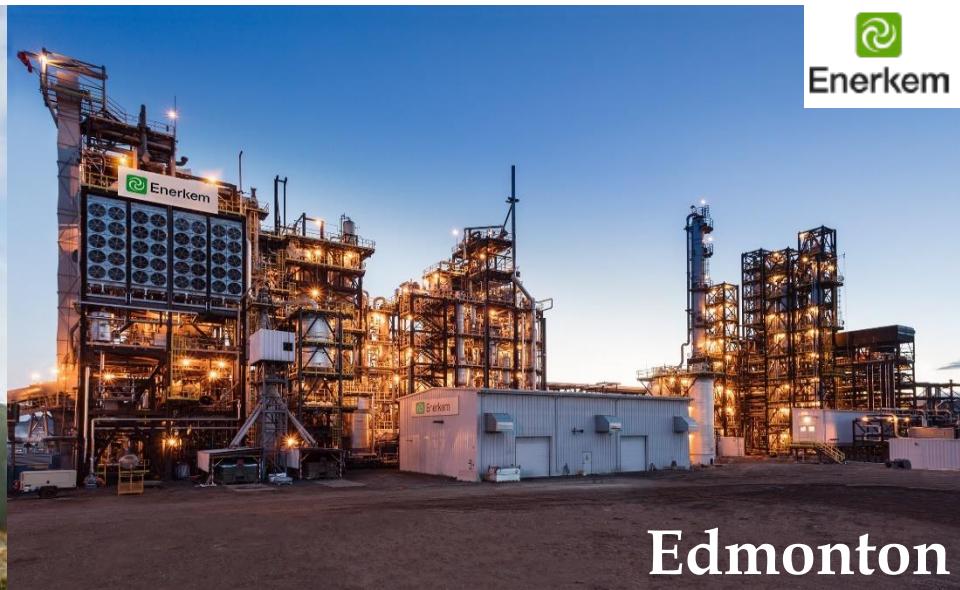
 Göteborg Energi



GoBiGas

CA

 Enerkem



Edmonton

30 MWth biomass in  
20 MW bio-methane, 5 MW heat out  
TUW/Repotec/Valmet, Topsöe SNG  
Operation 2014, 2017-2018 highlights:

- MCR capacity reached
  - 1 800 uninterrupted hours
- Mothballing decision taken

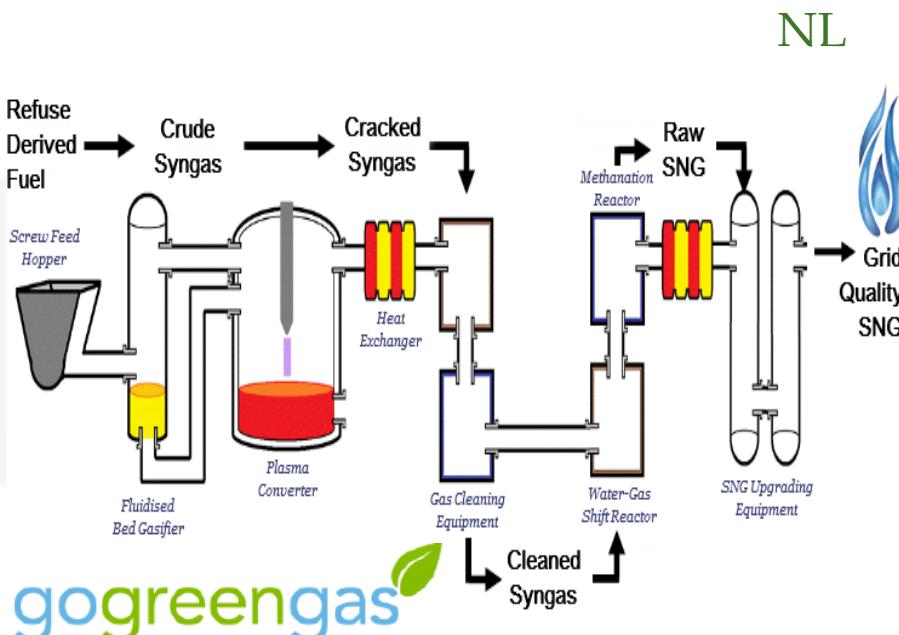
100 000 tons of RDF in  
38 000 m<sup>3</sup> of methanol/ethanol  
Univ. Sherbrooke/Enerkem technology  
Operation 2014, 2017-2018 highlights:

- MeOH to EtOH conv. installed
- Plans for project in Rotterdam
- ~220 M\$US from investors

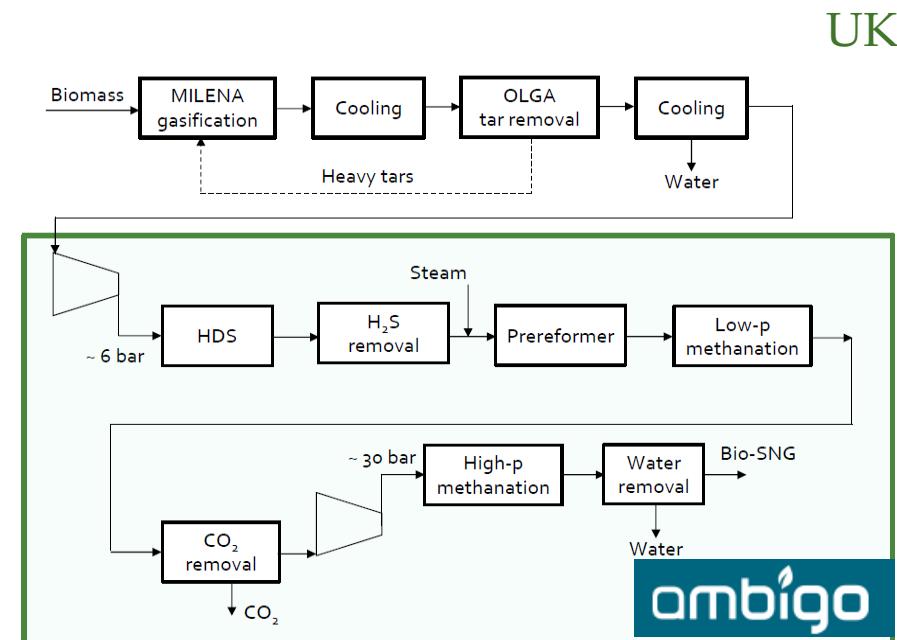
# Thermal gasification to biofuels

Developer/project		Feed	Year	Cap. MWth	Type	Status
Ambigo	NL	LC Biomass		4	SNG	Demo
Bioliq	DE	PO+char	2013	5	feed	Demo
BioTFuel	DE/FR	Torr. ag. resid.	2017	15	feed	Demo
Enerkem	CA	RDF	2014	30	EtOH	1 <sup>st</sup> ind.
	NL	Plastic waste		220	MeOH	Comm.
EON Bio2G	SE	LC biomass		200	SNG	1 <sup>st</sup> ind.
Fulcrum	USA	RDF		50	BTL	1 <sup>st</sup> ind.
Gobigas	SE	LC biomass	2013	20	SNG	1 <sup>st</sup> ind.
GoGreenGas	UK	RDF	2018	4	SNG	Demo
GTI	USA+	LC biomass	2009	2	BTL	Demo
Kaidi Ajos	FI/CN	LC biomass		300	BTL	1 <sup>st</sup> ind.
LTU Green Fuels	SE	Black liquor, PO	2009	1	DME	Demo
Red Rock	USA	LC biomass		75	BTL	1 <sup>st</sup> ind.
Sekisui/Lanzatech	JP/NZ	MSW	2013		EtOH	Pilot
						†2017

# Short-term op. or planned gasification to SNG plants, EU



NL



UK

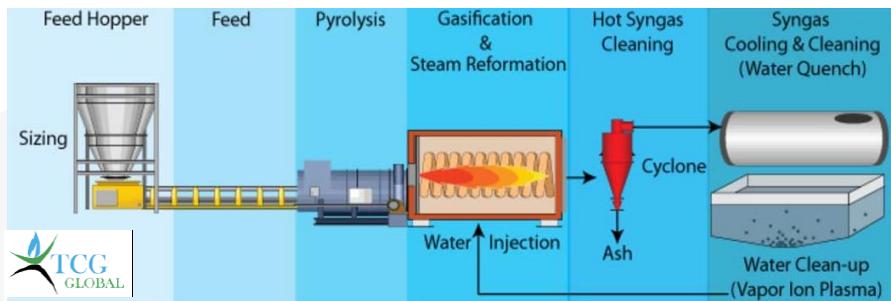
Start-up 2018 RDF feedstock  
4 MW bio-methane output  
Outotec gasifier, APP plasma  
AMEC FW VESTA SNG  
27 M£ cost, 11+5 M£ support  
Cadent (8.7 M£), APP, Carbotech,  
Progressive Energy, AMEC FW.

Biomass feedstock

4 MW bio-methane output  
ECN Milena gasifier, OLGA, ESME SNG  
25 M€, cost, 6.5 M€ support  
Engie, Gasunie, ECN, Royal Dahlman,  
Synnova , PDENH.



# Short-term op. or planned gasification to biofuel plants, USA



150 000 tonnes/year biomass in  
57 000 m<sup>3</sup>/year of BTL products  
TC Global gasifier  
Velocys microchannel FT  
~ 200 M\$, 74 M\$ DPA funding (DoD)



160 000 tones/year MSW (before MTP)  
40 000 m<sup>3</sup>/year of BTL products  
Thermochem Recovery Int. gasifier  
Emerging Fuels Technology FT  
~ 280 M\$, 70 M\$ DPA funding (DoD),  
Air BP and UA invested 30 M\$ each.

# Pyrolysis, catalytic pyrolysis and hydropyrolysis to bio-oils

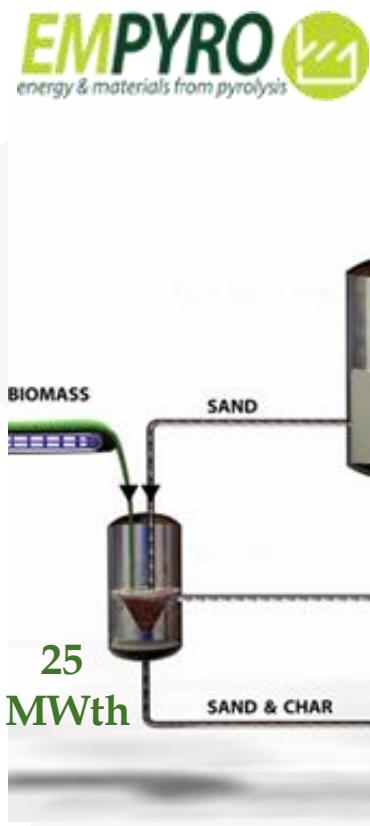
Company	Site	Feed	Year	Cap. ML/yr	Type	Status
Empyro (BTG)	NL	Wood resid.	2015	20	1 <sup>st</sup> ind.	Op.
Ensyn	CA	Wood resid.	2006, 15	20	Com.	Op.
Fortum	FI	Wood resid.	2014	50	1 <sup>st</sup> ind.	Op.
KIT	DE	Ag. residue	2010	2	Demo	
Metsä	SE	Wood resid.	2022	22	Com.	Plan
<b>Catalytic pyrolysis</b>						
Anellotech	USA	Wood resid.	2018	n.a.	Pilot	Op.
Fraunhofer Inst.	DE, UK	Various	2015	7 tpd feed	Pilot	Op.
<b>Hydropyrolysis</b>						
IH2	INDIA	Wood resid	2017	5 tpd feed	Demo	Com.
G4 Insights	USA	Wood resid	2017	0.1 tpd feed	Pilot	Op.

# Pyrolysis, catalytic pyrolysis and hydropyrolysis to bio-oils

Company	Site	Feed	Year	Cap. ML/yr	Type	Status
Empyro (BTG)	NL	Wood resid.	2015	20	1 <sup>st</sup> ind.	Op.
Ensyn	CA	Wood resid.	2006, 15	20	Com.	Op.
Fortum	FI	Wood resid.	2014	50	1 <sup>st</sup> ind.	Op.
KIT	DE	Ag. residue	2010	2	Demo	
Metsä	SE	Wood resid.	2022	22	Com.	Plan
<b>Catalytic pyrolysis</b>						
Anellotech	USA	Wood resid.	2018	n.a.	Pilot	Op.
Fraunhofer Inst.	DE, UK	Various	2015	7 tpd feed	Pilot	Op.
<b>Hydropyrolysis</b>						
IH2	INDIA	Wood resid	2017	5 tpd feed	Demo	Com.
G4 Insights	USA	Wood resid	2017	0.1 tpd feed	Pilot	Op.

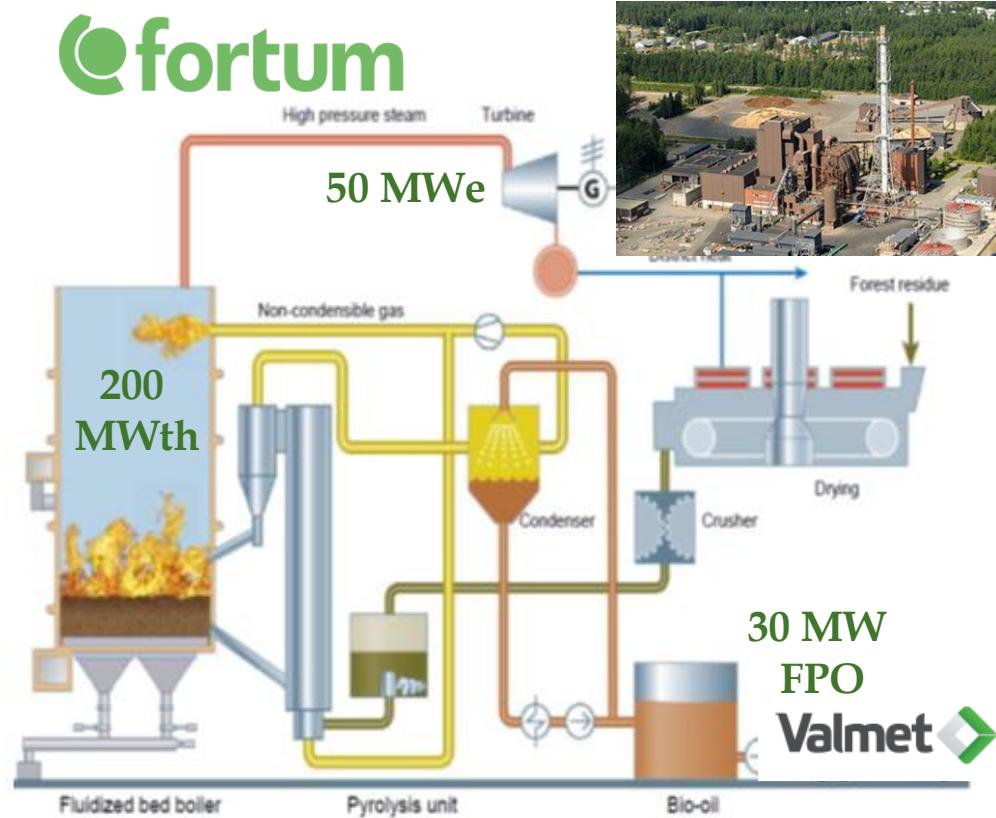
**Fast pyrolysis (~1-2 s, 450–550°C), op. plants, in EU**

NL



120 tonnes/d woody biomass  
20 000 m<sup>3</sup>/y FPO +steam+0.5 MWe  
U. Twente/BTG rotating cone proc.  
19 M€, support from FP7

FI



100 000 tonnes/y woody biomass  
50 000 m<sup>3</sup>/y of FPO products  
VTT/Valmet CFB process. 200 MW<sub>th</sub>  
~ 32 M€ (excl. boiler plant), 8 M€ support

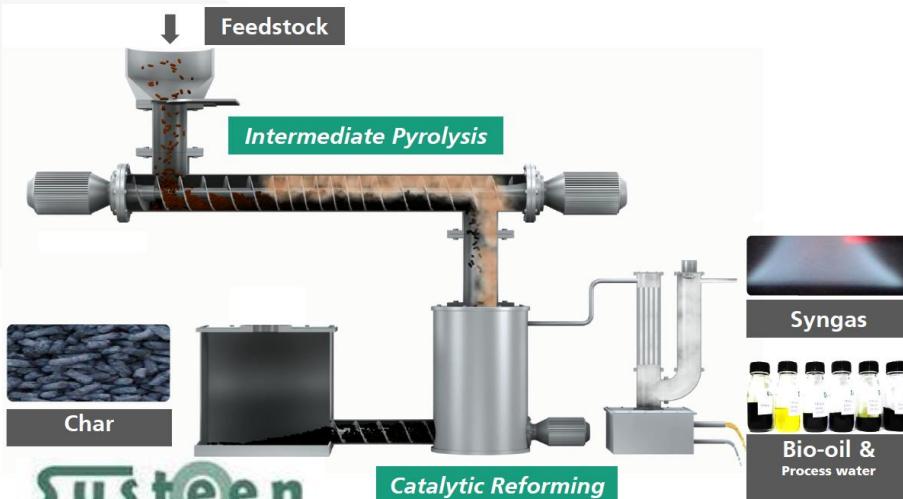
# Pyrolysis, catalytic pyrolysis and hydropyrolysis to bio-oils

Company	Site	Feed	Year	Cap. ML/yr	Type	Status
Empyro (BTG)	NL	Wood resid.	2015	20	1 <sup>st</sup> ind.	Op.
Ensyn	CA	Wood resid.	2006, 15	20	Com.	Op.
Fortum	FI	Wood resid.	2014	50	1 <sup>st</sup> ind.	Op.
KIT	DE	Ag. residue	2010	2	Demo	
Metsä	SE	Wood resid.	2022	22	Com.	Plan
<b>Catalytic pyrolysis</b>						
Anellotech	USA	Wood resid.	2018	n.a.	Pilot	Op.
Fraunhofer Inst.	DE, UK	Various	2015	7 tpd feed	Pilot	Op.
<b>Hydropyrolysis</b>						
IH2	INDIA	Wood resid	2017	5 tpd feed	Demo	Com.
G4 Insights	USA	Wood resid	2017	0.1 tpd feed	Pilot	Op.

# Catalytic pyrolysis and hydropyrolysis installations

DE

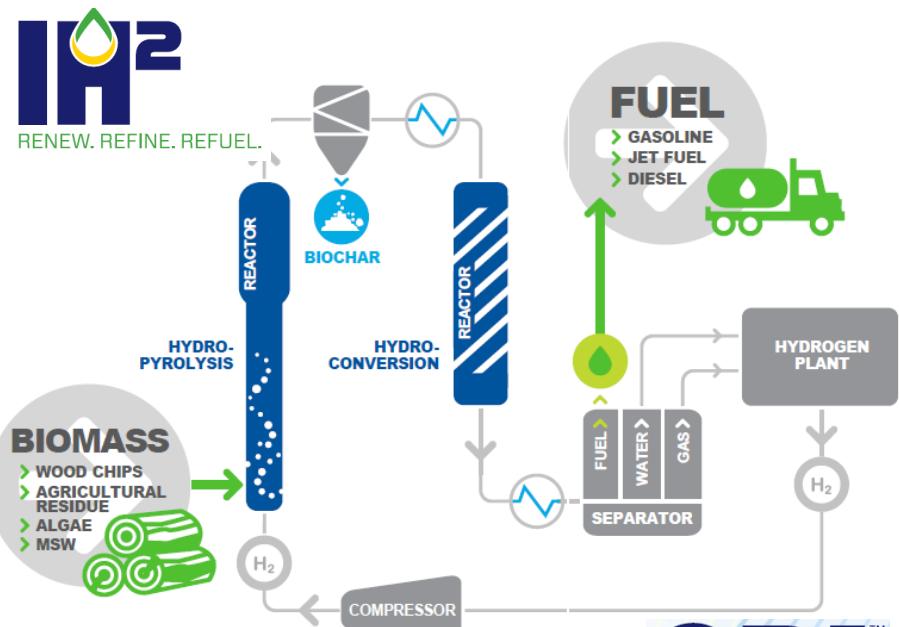
Thermo-Catalytic Reforming  **Fraunhofer**  
**UMSICHT**  
(TCR®) technology



**Susteen**  
Technologies GmbH

Slow pyrolysis, 4-10 min, at  $\sim 450^{\circ}\text{C}$ ,  
catalytic (char) reforming at  $\sim 750^{\circ}\text{C}$   
80 kg/h pilot op., 300 kg/h commis.  
H2020 projects 2 SynFuels and FlexJet  
to establish 500 kg/hr units.

INDIA

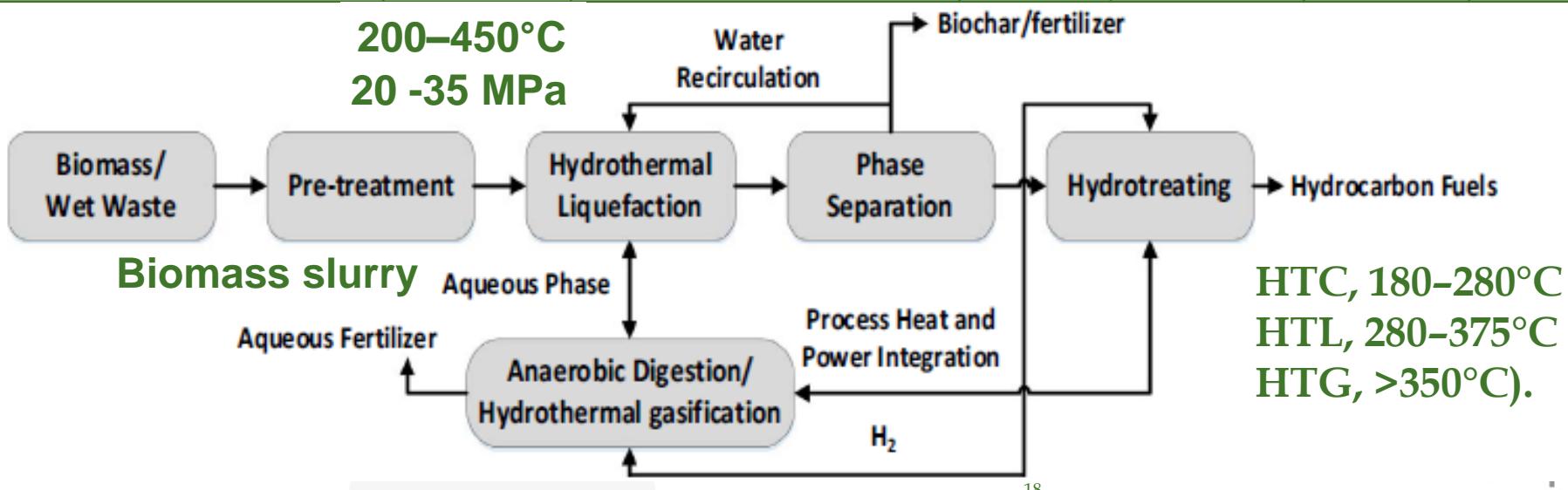


**CRI**  
DELIVERING INNOVATION

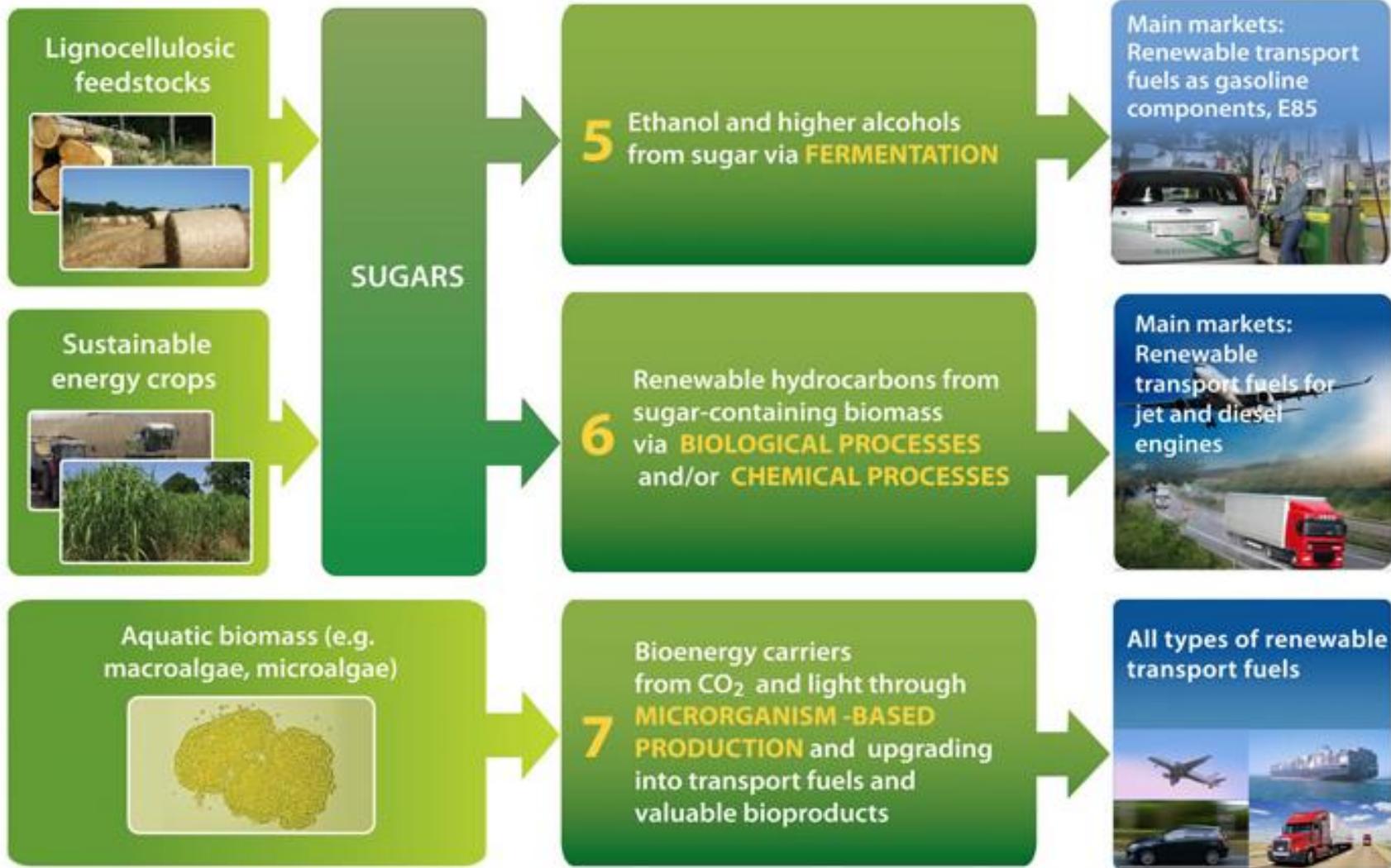
Catalytic hydropyrolysis in hydrogen at  
 $400\text{--}550^{\circ}\text{C}$ , 2-3 MPa pressure.  
Demo in India 5 tonnes/d feed 2017  
Developed by GTI and licensed to CRI  
Studies for 1<sup>st</sup> ind. plants in NO and IN

# Hydrothermal processing to intermediates and gas

Company	Site	Feed	Year	Cap. ML/yr	Type	Status
Licella (HTL)	AU	Various	2012	?	Demo	Com.
Licella/Canfor	CA	Wood & pulp res.		?	1 <sup>st</sup> ind.	Plan.
Silva Green Fuels	NO	Wood residues	2019	1.4	Demo	Plan.
Steeper AAU (HTL)	DK/CA					
SCW systems (HTG)	NL	Wet biomass	2017	2 MW 20 MW	Demo 1 <sup>st</sup> ind.	Op. Plan.



# Biochemical & chemical conversion value chains



# Lignocellulosic ethanol facilities

Company	Site	Feed	Year	ML/yr	Type	Status
Abengoa	ES	Ag. res. MSW	2008	5	Demo	Idle
Beta Renewables	IT	Ag. resid.	2013	76	1st ind.	Idle
Energochemic	SL	Ag. resid.	2017	70	Comm	Constr.
CIMV	FR	Ag. resid.	2017	0.9	Demo	Op.
Clariant	DE	Ag. resid.	2012	1.2	Demo	Op.
DuPont (largest one)	USA	Ag. resid.	2016	114	1 <sup>st</sup> ind.	Idle
Granbio	BR	Bagasse	2014	82	1st ind.	Com.
Futurol	FR	Ag. resid.	2011	0.18	Demo	Op.
Inbicon (Kalundborg)	DK	Straw	2009	6	Demo	Idle
POET/DSM	USA	Ag. resid.	2014	76	1 <sup>st</sup> ind.	Com.
Raizen	BR	Bagasse	2015	40	1 <sup>st</sup> ind.	Com.
Borregaard	NO	Woody bm	2013	0.14	Demo	Op.
RISE (ex-SEKAB)	SE	Woody bm	2004	0.15	Pilot	Op.
ST1	FI	Woody bm	2017	10	Demo	Com.
Synata (ex-Abengoa)	USA	Ag. Resid.	2016	95	1 <sup>st</sup> Ind.	Idle

# Lignocellulosic ethanol facilities

Company	Site	Feed	Year	ML/yr	Type	Status
Abengoa	ES	Ag. res. MSW	2008	5	Demo	Idle
Beta Renewables	IT	Ag. resid.	2013	76	1st ind.	Idle
Energochemic	SL	Ag. resid.	2017	70	Comm	Constr.
CIMV	FR	Ag. resid.	2017	0.9	Demo	Op.
Clariant	DE	Ag. resid.	2012	1.2	Demo	Op.
DuPont (largest one)	USA	Ag. resid.	2016	114	1 <sup>st</sup> ind.	Idle
Granbio	BR	Bagasse	2014	82	1st ind.	Com.
Futurol	FR	Ag. resid.	2011	0.18	Demo	Op.
Inbicon (Kalundborg)	DK	Straw	2009	6	Demo	Idle
POET/DSM	USA	Ag. resid.	2014	76	1 <sup>st</sup> ind.	Com.
Raizen	BR	Bagasse	2015	40	1 <sup>st</sup> ind.	Com.
Borregaard	NO	Woody bm	2013	0.14	Demo	Op.
RISE (ex-SEKAB)	SE	Woody bm	2004	0.15	Pilot	Op.
ST1	FI	Woody bm	2017	10	Demo	Plan.
Synata (ex-Abengoa)	USA	Ag. Resid.	2016	95	1 <sup>st</sup> Ind.	Idle

# BetaRenewables, Crescentino, Italy



First Commercial Cellulosic ethanol industrial scale plant in the world – start up 2013

270,000 ton/yr straw; 60 000 ton/year of ethanol , 13MWe generated from lignin. Production process: uncatalysed steam explosion (Proesa®), EH + Co-Fermentation C5+C6 sugars

# BetaRenewables, Crescentino, Italy



MILANO FINANZA 17/10/2017 Mossi Ghisolfi va al concordato



First cellulosic ethanol industrial scale plant in the world – start up 2013

270,000 ton/yr straw, 60,000 ton/year of ethanol , 13MWe generated from lignin. Production process: uncatalysed steam explosion (Proesa ®), EH + Co-Fermentation C5+C6 sugars

# Poet/DSM (Project Liberty)

**Local:** Emmetsburg, Iowa, USA

**Start-up:** 2014

**Raw material:** corn stover (285,000 ton/year); 45-miles radius.

**Product:** Ethanol (60,000 ton/year) + biogas + CHP (from lignin)

**Production process:** Two-stage diluted acid pretreatment, C5+C6 fermentation; Co-location with an existing dry mil corn plant



1st Commercial

# Raízen (Brazil)

**Local:** Piracicaba - SP, Brazil

**Start-up:** 2015

**Raw material:** sugar cane bagasse and straw.

**Product:** Ethanol (32,000 ton/year) + electricity. Co-location with an existing 1G bioethanol plant from sugar cane.

**Production process:** logen's technology – acid-catalysed steam explosion, EH and Fermentation

In  
operation

Commercial



# Lignocellulosic ethanol facilities

Company	Site	Feed	Year	ML/yr	Type	Status
Abengoa	ES	Ag. res. MSW	2008	5	Demo	Idle
Beta Renewables	IT	Ag. resid.	2013	76	1st ind.	Idle
Energochemic	SL	Ag. resid.	2017	70	Comm	Constr.
CIMV	FR	Ag. resid.	2017	0.9	Demo	Op.
Clariant	DE	Ag. resid.	2012	1.2	Demo	Op.
DuPont (largest one)	USA	Ag. resid.	2016	114	1 <sup>st</sup> ind.	Idle
Granbio	BR	Bagasse	2014	82	1st ind.	Com.
Futurol	FR	Ag. resid.	2011	0.18	Demo	Op.
Inbicon (Kalundborg)	DK	Straw	2009	6	Demo	Idle
POET/DSM	USA	Ag. resid.	2014	76	1 <sup>st</sup> ind.	Com.
Raizen	BR	Bagasse	2015	40	1 <sup>st</sup> ind.	Com.
Borregaard	NO	Woody bm	2013	0.14	Demo	Op.
RISE (ex-SEKAB)	SE	Woody bm	2004	0.15	Pilot	Op.
ST1	FI	Woody bm	2017	10	Demo	Plan.
Synata (ex-Abengoa)	USA	Ag. Resid.	2016	95	1 <sup>st</sup> Ind.	Idle

# Clariant (ex- Sud-Chemie)

**Local** : Straubing (Germany)

**Start-up**: 2012

**Raw material**: cereal straw, agricultural waste

**Product**: Ethanol (1.000 ton/year)

**Production process**: steam explosion pre-treatment, enzymatic hydrolysis and co-fermentation of C<sub>5</sub> and C<sub>6</sub>

Demo



# Inbicon/Dong Energy

**Local:** Kalundborg (Denmark) – Demo plant

**Start-up:** 2009

**Raw material:** 30.000 ton/year wheat straw

**Product:** Ethanol (4.300 ton/year), C<sub>5</sub> molasses, lignin for energy

**Production process:** Hydrothermal pre-treatment, enzymes from Novozymes, enzymatic hydrolysis and co-fermentation of C<sub>6</sub> (phase 1); C5+C6 co-fermentation (phase 2). Stand-alone plant.

Stop in  
2016

Demo



# Borregaard Industries AS

**Local:** Sarpsborg (Norway)

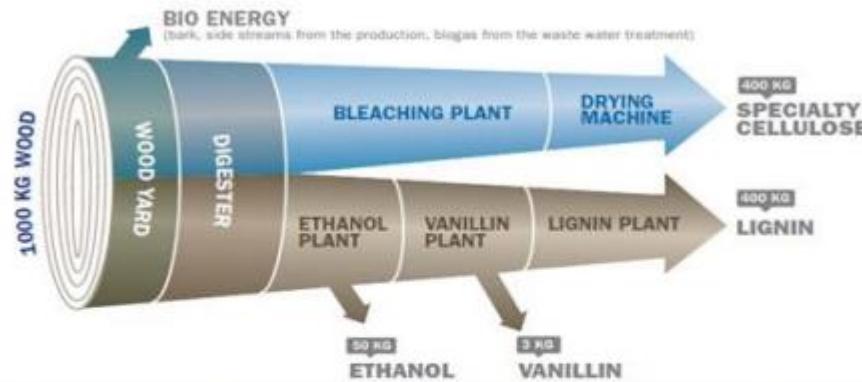
**BALI™ technology**

**Start-up:** 2013

**Raw material:** 50 kg/h; cereal straws, sugarcane bagasse

**Product:** Ethanol (110 ton ethanol/year or 22º ton sugars C<sub>5</sub>/C<sub>6</sub>/year; 200 ton/year specialized products of lignin)

**Production process:** (BALI Technology); Biorefinery concept (chemical pretreatment, HE, Fermentation)



[www.borregard.com](http://www.borregard.com)



Cellulose	Lignin	Vanillin	Ethanol
Construction materials	Concrete additives	Food	Carcare
Cosmetics	Animal feed	Perfumes	Paint/varnish
Food	Dyestuff	Pharmaceuticals	Pharmaceutical industry
Tablets	Batteries		Bio Fuel
Textiles	Briquetting		
Filters	Mining		
Paint/ varnish			

Demo

# Short term: Developments on lignocellulosic ethanol



Announced plans for plants in SL, RO.



April 2017

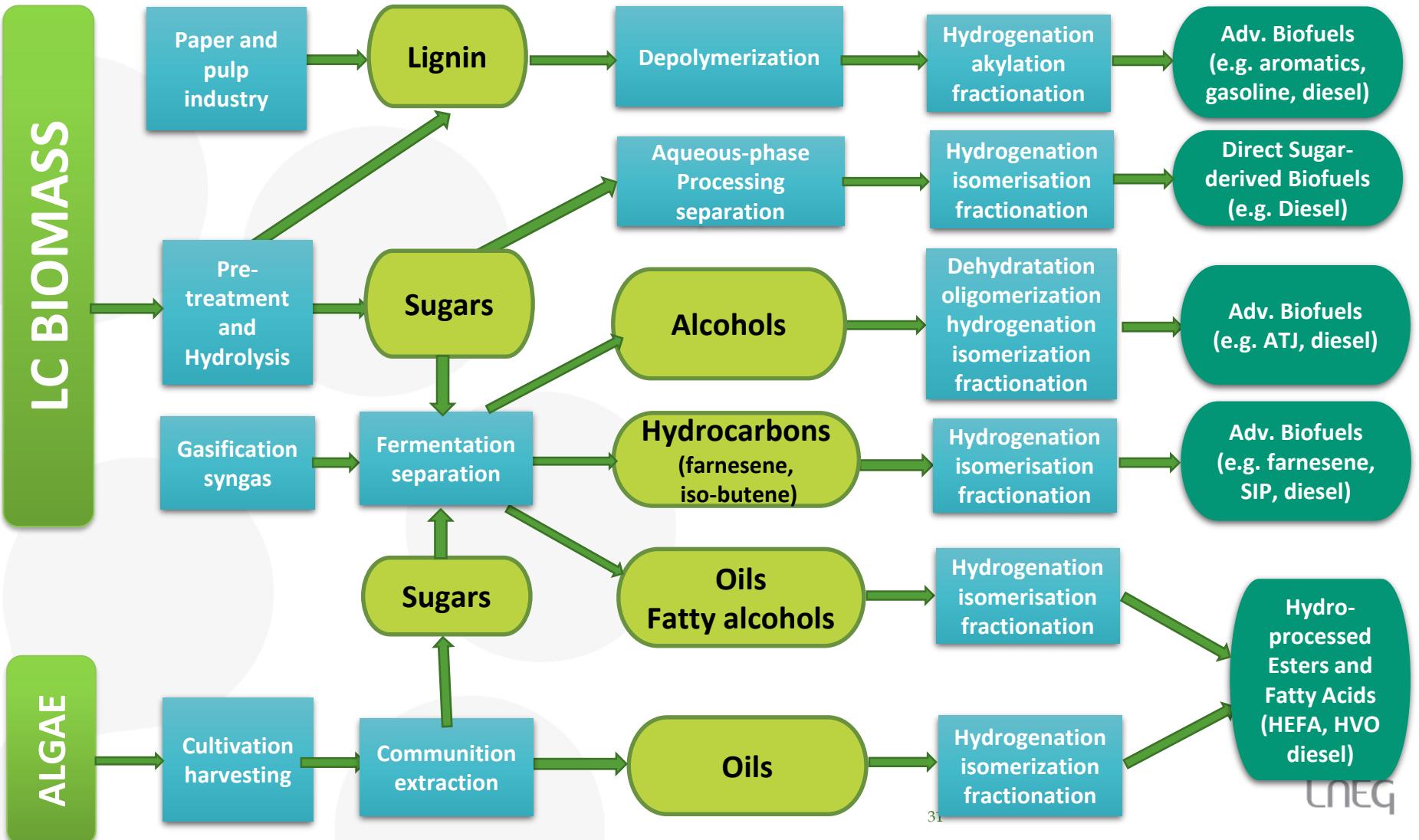
LoI with Pioneer Point Partners for an investment up to 160 M€ in the MEC plant conditional on political framework and long-term government support is settled .



PRAJ: Capacity 1 million liters ethanol from ag. residue  
End-to-end integrated demonstration plant  
Commissioning 2017 -



# Intermediates to hydrocarbons



# Sugars and syngas to higher alcohols and hydrocarbons

Company	Site	Products	Year	Cap. ML/yr	Type	Status
Amyris	2*NZ KO, AU	Various non-fuel		50 70	Comm. Comm.	Plan Plan.
DSM (ex-Amyris)	BR	Farnesene	2012	40	1 <sup>st</sup> ind.	Op.?
BUTAMAX	UK USA	Iso-butanol	2012	0.2	Demo 1 <sup>st</sup> ind.	Com. Plan.
GEVO	USA	Iso-butanol	2014	6	1 <sup>st</sup> ind.	Com.
Global Bioenergies	FR	Iso-butene	2017	100 tpa	Demo	Op.
REGI (LS9)	USA	Fatty alcohols	2012	0.13	Demo	Op.
VIRENT	USA	Various fuel/ non-fuel	2009 2013	~ 0.04 ~ 0.02	Demo Demo	Op. Op.
<b>Syngas (CO+H2) to alcohol</b>						
Lanzatech	USA	Ethanol Fatty alcohols	2018	60	Demo Dev.	Constr.

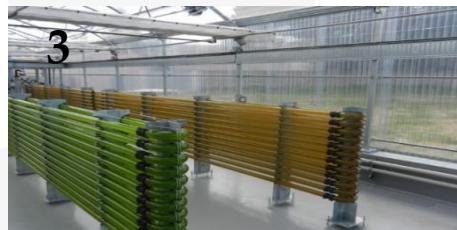
# Alcohols to hydrocarbons

Company	Site	Feed	Year	Cap. ML/yr	Type	Status
<b>Main product diesel and jet</b>						
Gevo	USA	Iso-butanol	2011	0.5	Demo	Op.
Byogy	USA	Ethanol	2017		Demo	Op.
Sw. Biofuels	SE	Alcohols	2012	0.01	Pilot	Op.
Lanzatech	NZ(USA)	Ethanol	2015		Pilot	Op.
<b>Main product gasoline</b>						
Enerkem	CA	Methanol	2018		Pilot	Op.
Mobil MTG	USA	Methanol	1985	850	Com.	†1995
KIT	DE	Methanol	2014	0.7	Pilot	Op.
Lurgi MTS	DE	Methanol	2008		Pilot	2011
Topsöe TIGAS	DK	Methanol	2014	90	Com.	2018
Vertimass	USA	Ethanol				

# Microalgae – Demo Plants

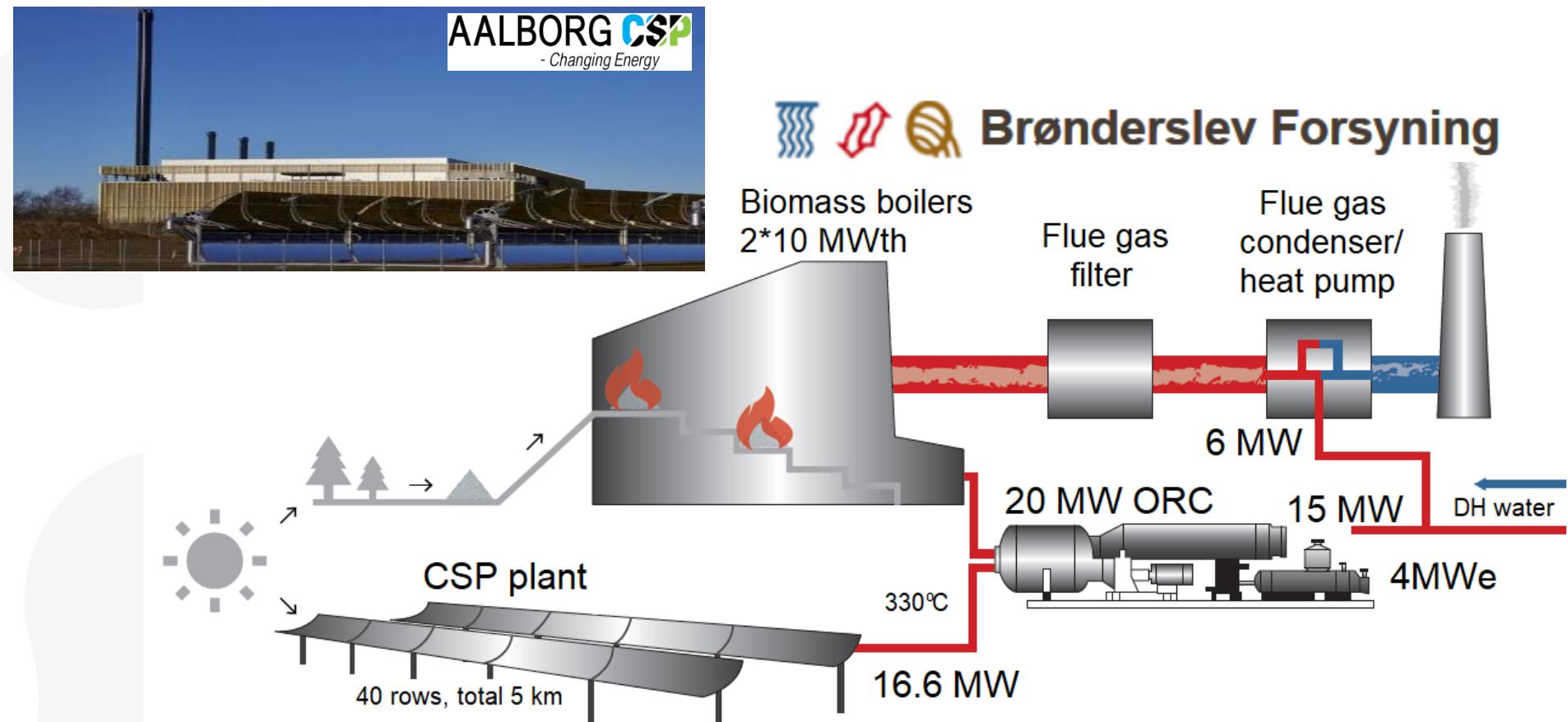
Company		Year	Type	Cap. kton dw/y	Product	Future
1	InteSusAl	PT	2015	Microalgae	0.04	Biodiesel
2	All-Gas	ES	2014	Microalgae	0.014	Biogas
3	Algafuel	PT	2014	GE $\mu$ -algae	0.001	Ethanol
4	Algae Tech	AU	2018	Microalgae	Pilot (IN)	Biofuel

Many e.g. Algenol, Biofat, BuggyPower, Sapphire, Joule, Solazyme, Helliae, Allmicroalgae have shifted from biofuel to non-fuel products in 2014-2017



# Hybrids: Power & heat integration with other RES

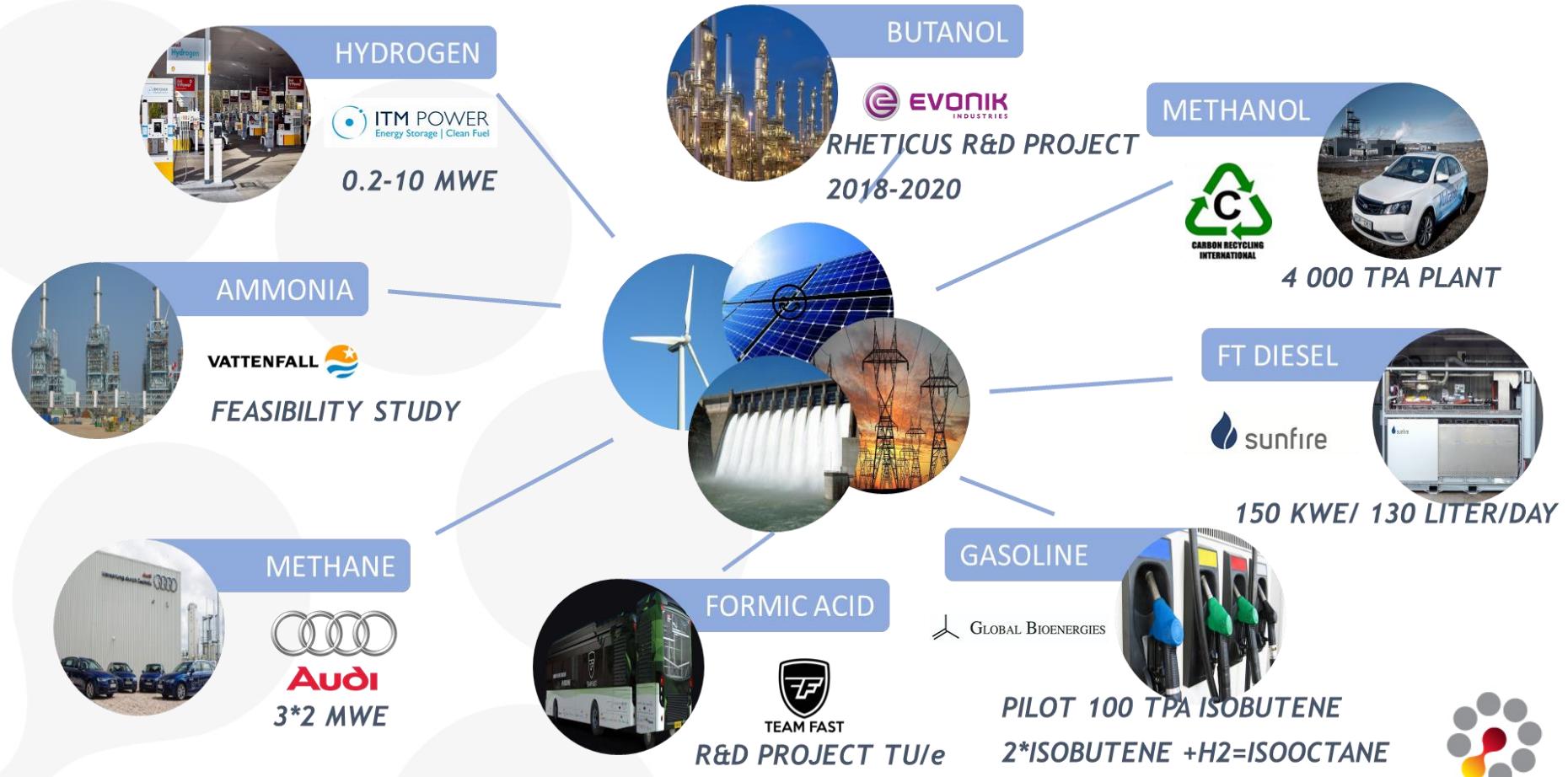
Brønderslev DK: First hybrid CSP/biomass ORC CHP Plant



Technology provider: Aalborg CSP A/S. Total cost 35 M€, 2 M€ in support

# Power-to-X; some examples

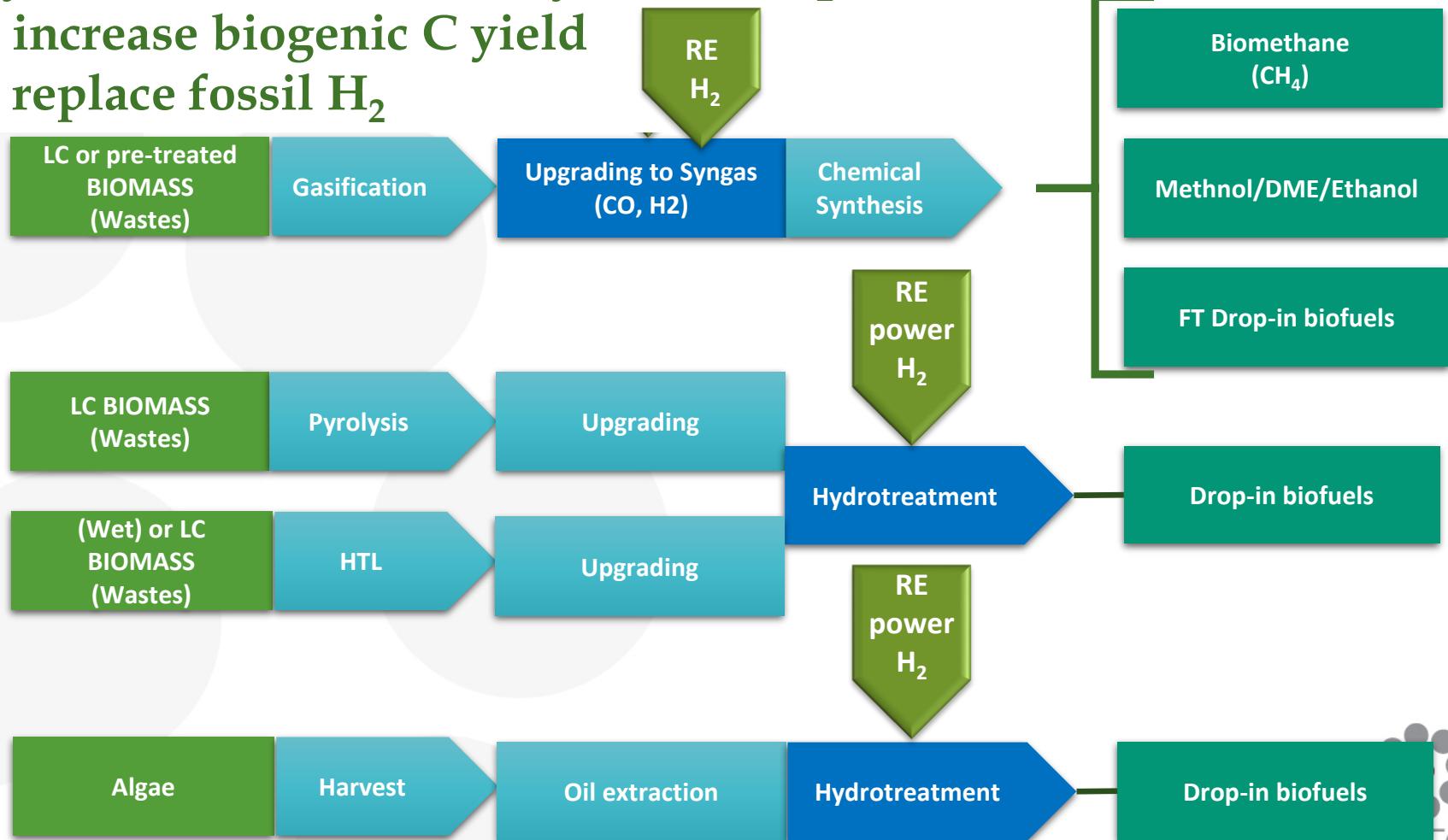
MANY MORE EXAMPLES EXIST



# Power-to-biofuels

Hybrid biofuels efficiently utilizes H<sub>2</sub> to :

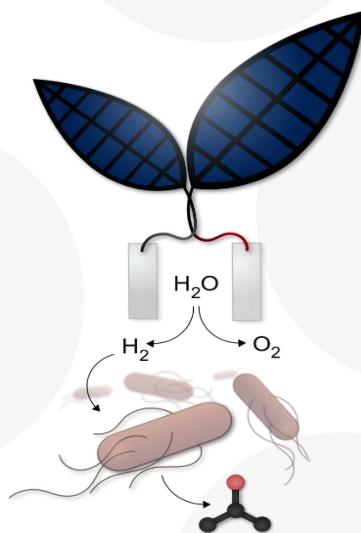
- ✓ increase biogenic C yield
- ✓ replace fossil H<sub>2</sub>



# Examples of novel ideas in early stage development

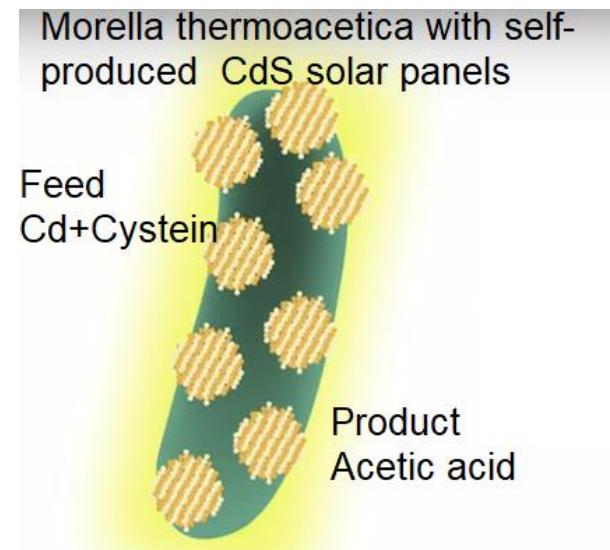
**Bionic leafs** which uses solar light to split water into hydrogen and oxygen, combined with another microorganism consumes hydrogen and carbon dioxide to produce hydrocarbons, e.g. iso-propanol

Source The Conversation 2015-02-12

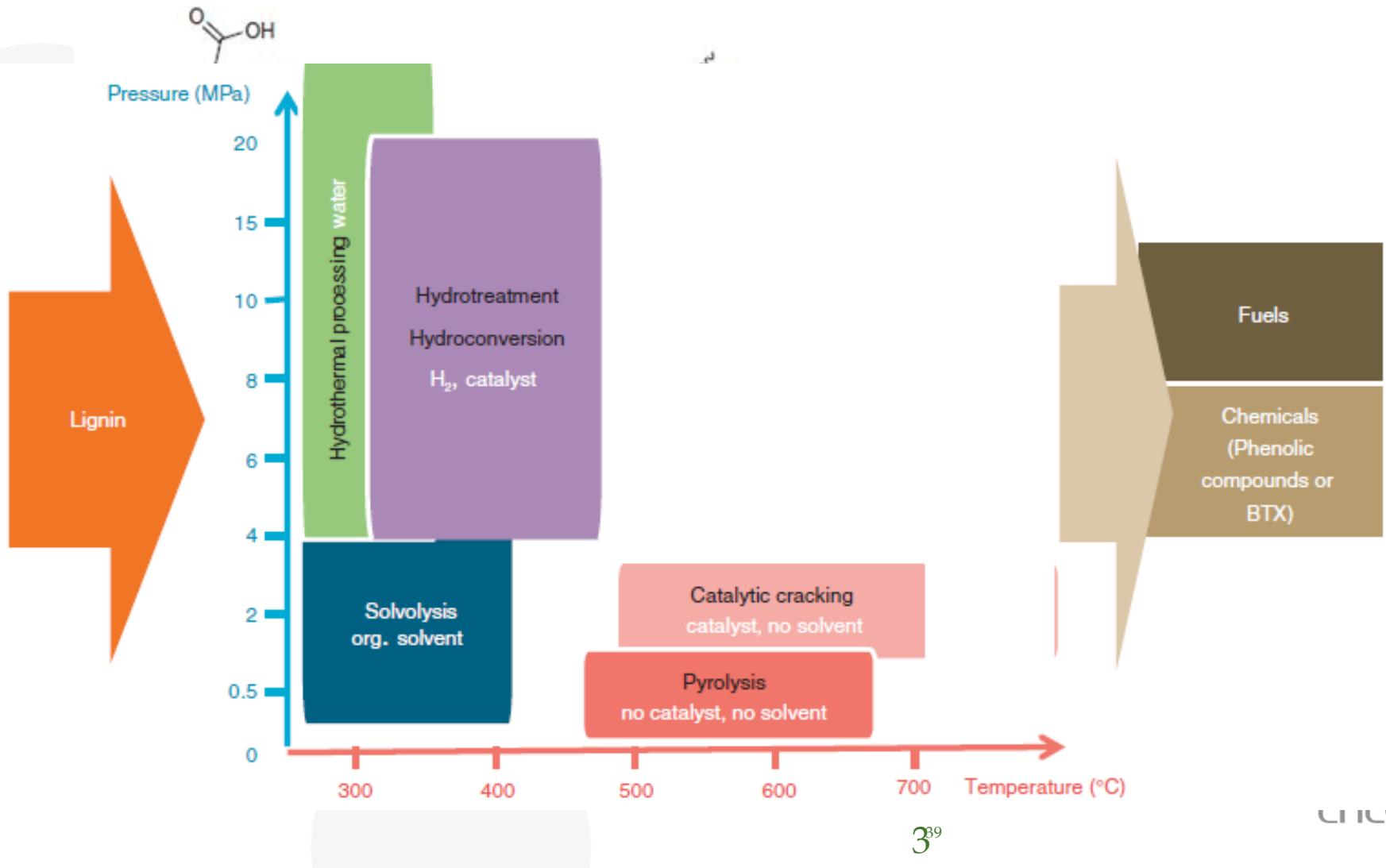


**Bio-solar cell factories (BSCF)**, in which phototrophic micro-organisms (e.g. cyanobacteria, eukaryotic algae) directly catalyze the conversion of CO<sub>2</sub> and H<sub>2</sub>O into oxygen and chemical energy, e.g. fuel molecules.

Source CleanTechnica 2017-08-22



# Lignin depolymerization



# Lignin extraction and upgrading

Company		Feed	Process	BL lignin Prod	Status
Valmet	FI	Black liquor	Precipitation	Lignoboost	Industrial
Suncarbon	SE	Black liquor	Membrane filtr.	Lignin concent.	Pilot
Company		Feed	Process	Upgrading	Status
Beta Renew.	IT	Hydrolysis	Hydrogenolysis	Hydrogenation	Pilot
RenFuel,	SE	BL lignin	Thermal	Esterification. Refinery.	Pilot
SCA	SE	Black liquor	n.a.	n.a.	Pilot
Suncarbon	SE	BL lignin	HTL	Refinery	Bench
Licella	AU/CA	Black liquor	HTL	Refinery	Pilot
Lignojet	SE	BL lignin	Hydrogenolysis	Refinery	Bench
Chalmers	SE	Black liquor	Near SC	Refinery	Pilot

Other entities process lignin for non-fuel purposes (resins, phenols, plastics)

# Take-away messages

- Industrial implementation of advanced technologies based on Biomass requires patience.
- The economics of bridging the “development gap” from pilot R&D to operational 1<sup>st</sup> industrial plant is a main bottleneck for biofuels, in particular challenging for one-product start-ups.
- Support e.g. Investment Fund should be designed with this in mind to be effective in reaching the desired impact (nGeneration Biofuels).
- Also policy must be sustainable over time, not only biofuels

## ACKNOWLEDGMENT

[www.lneg.pt](http://www.lneg.pt)

**Lars Waldheim (Co-author)**

**[lars.waldheim@waldheim-consulting.se](mailto:lars.waldheim@waldheim-consulting.se)**

**MANY THANKS**

**[francisco.girio@lneg.pt](mailto:francisco.girio@lneg.pt)**