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Bioenergy and biofuels- Conversion technology developments

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It is not all about technology and innovation

Source Hedgeeye

Source AEBIOM

Demonstrating climate mitigation technologies: An early assessment of the NER 300 programme

Max Åhman [a], Jon Birger Skjærseth [b], Per Ove Eikeland [b]

Highlights

- The EU demonstration programme NER300 did only partly deliver as intended.
- CCS and large scale biofuels failed whereas as renewable electricity succeeded.
- The design put large-scale projects at a disadvantage.
- The wider energy and climate policy including demand pull did not deliver as intended.

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Collateral damage and other difficulties

FINANCIAL TIMES NOVEMBER 25, 2015

Renewables group Abengoa sends Spanish bank shares tumbling

MILANO FINANZA 17/10/2017

Mossi Ghisolfi va al concordato

DuPont to sell cellulosic ethanol plant in blow to biofuel

REUTERS NOVEMBER 2, 2017

Göteborg Energi 2018-04-03

Pressrelease: GoBiGas avslutas
men kan få en roll i framtidens energiförsörjning

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Thermochemical & chemical conversion value chains

Lignocellulosic feedstocks

1 Synthetic fuels / hydrocarbons from biomass via GASIFICATION → Renewable liquid transport fuels

2 Bio-methane from biomass via GASIFICATION → Substituting natural gas and other gaseous fuels

3 High efficiency power generation via GASIFICATION of biomass → Power and heat

4 Intermediate Bioenergy carriers via other thermochemical processes → Intermediates for upgrading into transport fuels, or fuels for heating and power generation

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Thermal gasification to biofuels

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

Operating gasification to biofuel plants

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

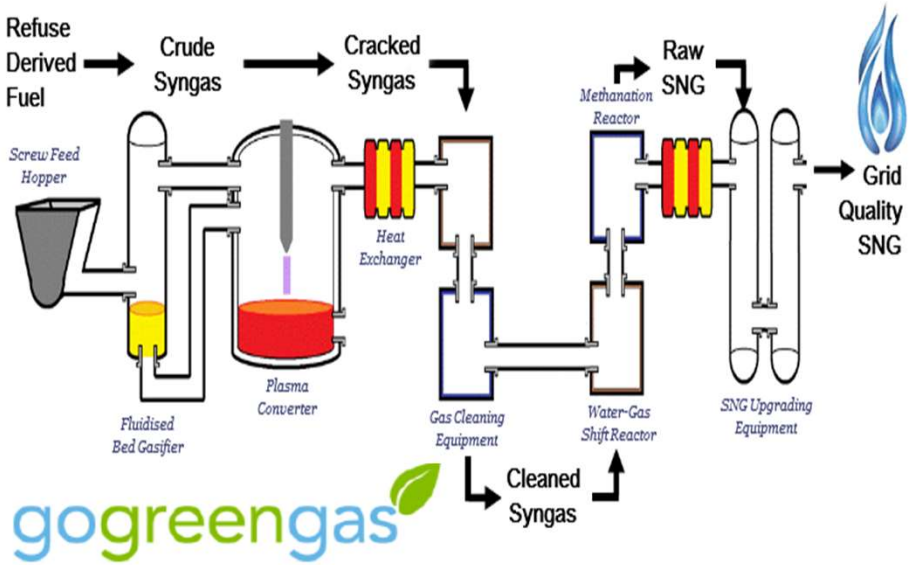
- MCR capacity reached
- 1 800 uninterrupted hours

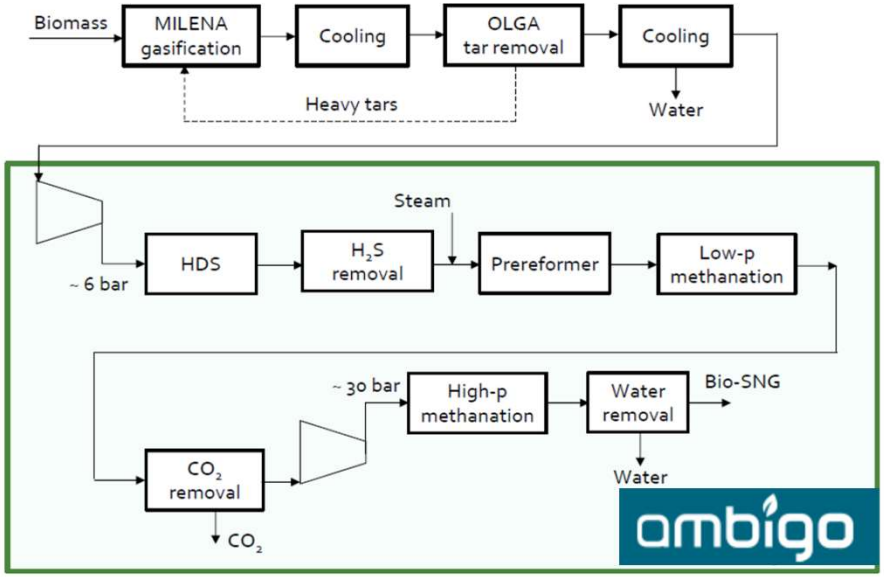
Mothballing decision taken

100 000 tons of RDF in
38 000 m3 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

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

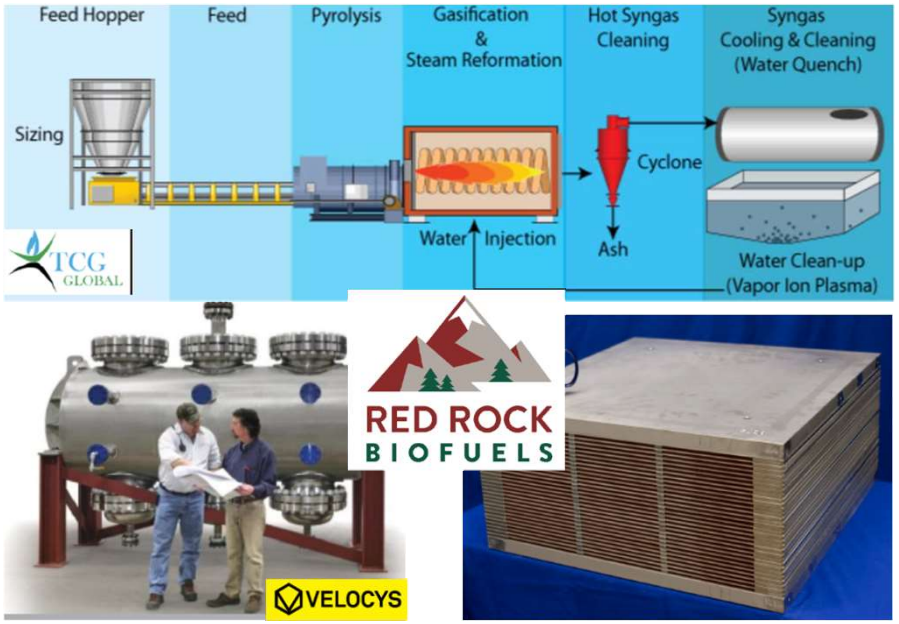




Start-up 2018 RDF feedstock
4 MW bio-methane output
Outotec gasifier, APP plasma
AMEC FW VESTA SNG
27 M£ cost, 11+5 M£ support
Cadent (8.7 M£), APP, Carbotech, Progressive Energy, AMEC FW.

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.

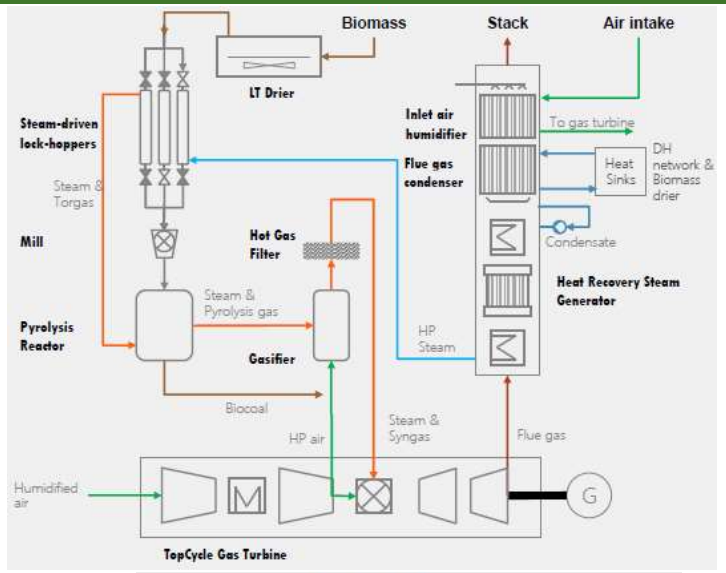
Short-term planned gasification to biofuel plants, USA

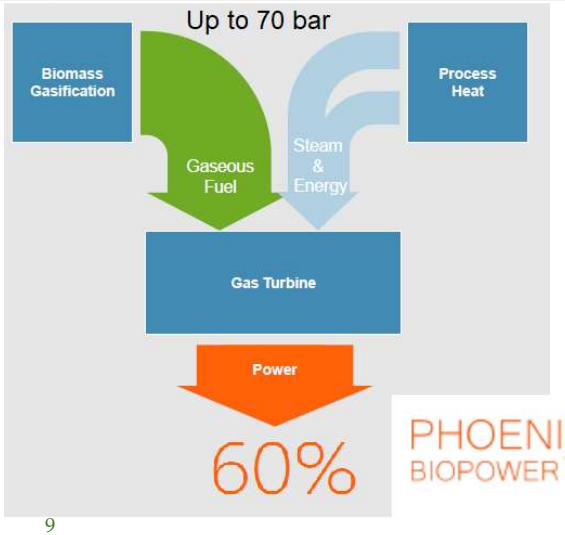


150 000 tonnes/year biomass in
57 000 m^3/year of BTL products
TC Global gasifier
Velocys microchannel FT
~ 200 M$, 74 M$ DPA funding (DoD)

160 000 tones/year MSW (before MTP)
40 000 m^3/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.

Power and heat at high efficiency





stockholm exergi

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

PHOENIX BIOPOWER

Pyrolys, catalytic pyrolysis and hydropyrolysis to biooils

Company	Site	Feed	Year	Cap. ML/yr	Type	Status
Empyro (BTG)	NL	Wood resid.	2015	20	1st ind.	Op.
Ensyn	CA	Wood resid.	2006, 15	20	Com.	Op.
Fortum	FI	Wood resid.	2014	50	1st ind.	Op.
KIT	DE	Ag. residue	2010	2	Demo	
Metsä	SE	Wood resid.	2022	22	Com.	Plan
Catalytic pyrolysis						
Anellotech	USA	Wood resid.	2018	n.a.	Pilot	Op.
Fraunhofer Inst.	DE, UK	Various	2015	7 tpd feed	Pilot	Op.
Hydropyrolysis						
IHI2	USA, IN	Wood resid	2017	5 tpd feed	Demo	Com.
G4 Insights	USA	Wood resid	2017	0.1 tpd feed	Pilot	Op.

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

EMPYRO
energy & materials from pyrolysis

btg-btl
biomass-to-liquid

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

fortum

100 000 tonnes/y woody biomass
50 000 m^3/y of FPO products
VTT/Valmet CFB process. 200 MWth
~ 32 M€ (excl. boiler plant), 8 M€ support

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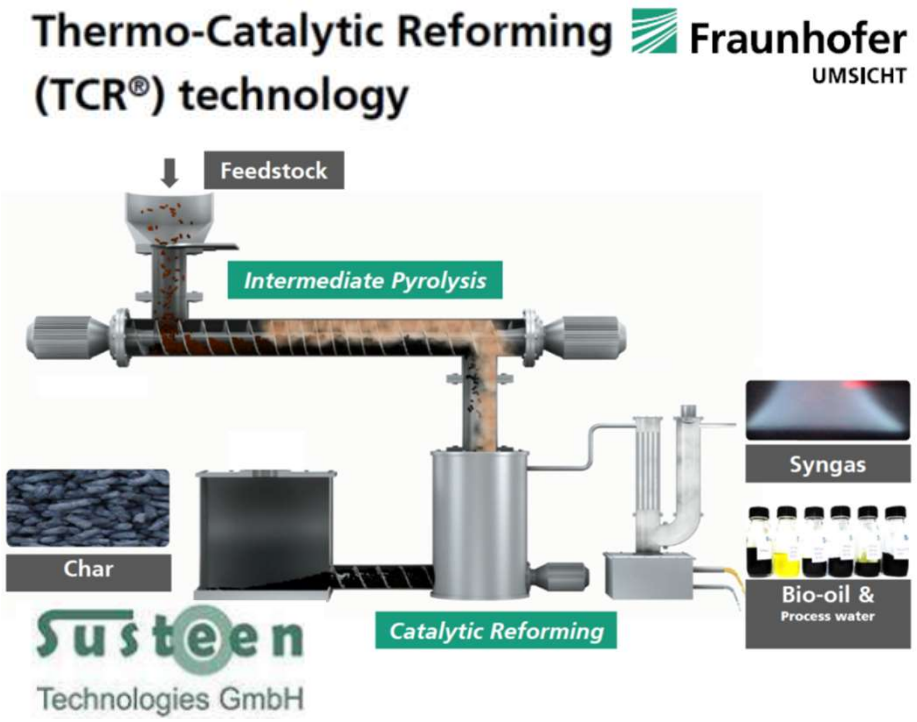
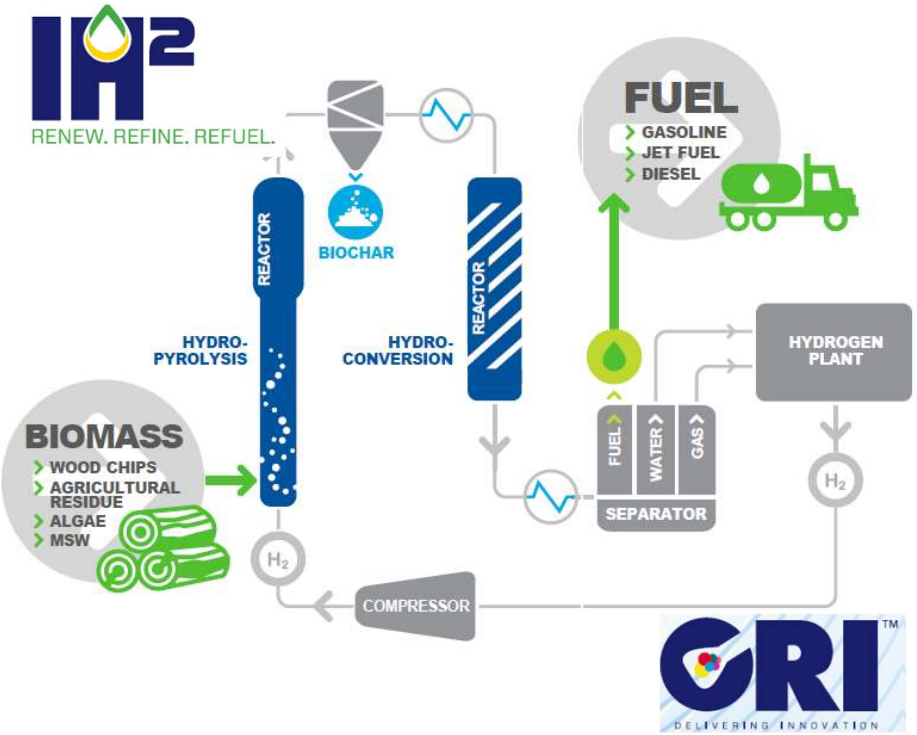
Catalytic pyrolysis and hydropyrolysis installations



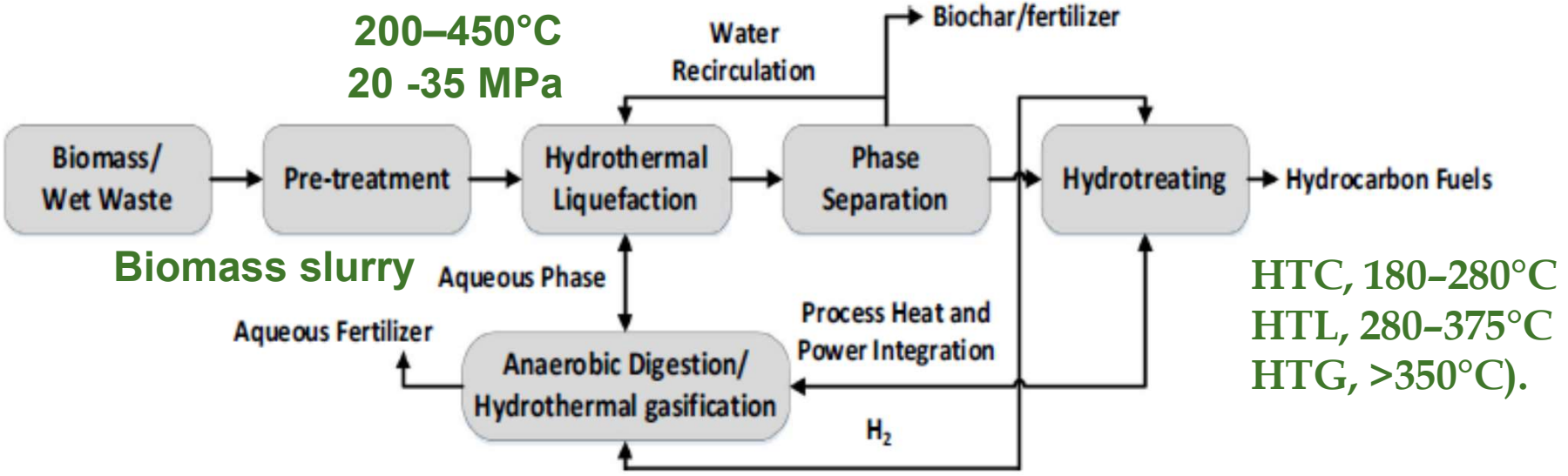


Slow pyrolysis, 4-10 min, at ~ 450°C, catalytic (char) reforming at ~ 750°C
80 kg/h pilot op., 300 kg/h commis.
H2020 projects 2 SynFuels and FlexJet to establish 500 kg/hr units.

Catalytic hydropyrolysis in hydrogen at 400–550°C, 2-3 MPa pressure.
Demo in India 5 tonnes/d feed 2017
Developed by GTI and licensed to CRI
Studies for 1st ind. plants in NO and IN

Hydrothermal processing to intermediates and gas

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



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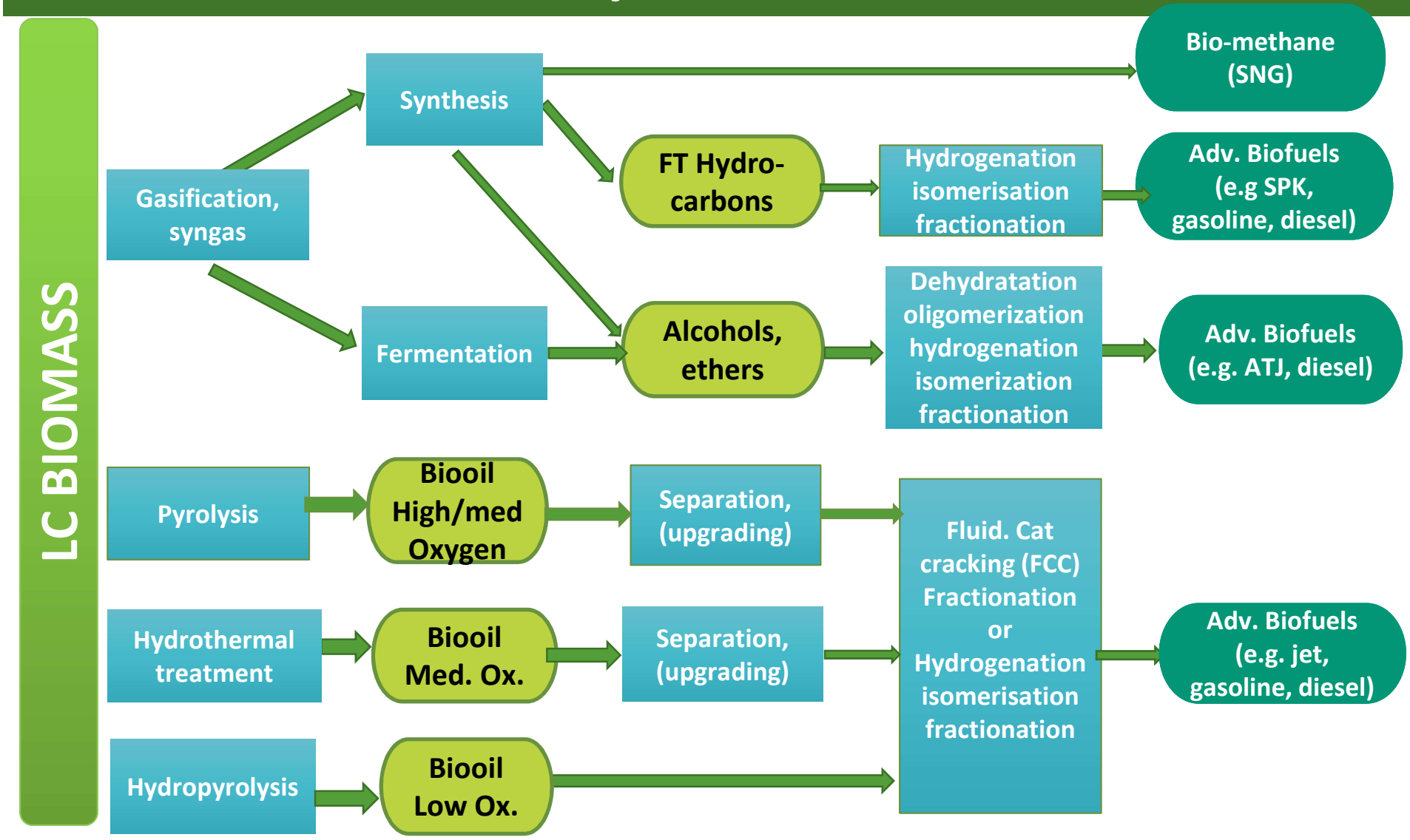
Intermediates to hydrocarbons



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Biochemical & chemical conversion value chains

Lignocellulosic feedstocks

Sustainable energy crops

SUGARS

Aquatic biomass (e.g. macroalgae, microalgae)

5 Ethanol and higher alcohols from sugar via FERMENTATION

6 Renewable hydrocarbons from sugar-containing biomass via BIOLOGICAL PROCESSES and/or CHEMICAL PROCESSES

7 Bioenergy carriers from CO_2 and light through MICRORGANISM -BASED PRODUCTION and upgrading into transport fuels and valuable bioproducts

Main markets: Renewable transport fuels as gasoline components, E85

Main markets: Renewable transport fuels for jet and diesel engines

All types of renewable transport fuels

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Lignocellulosic ethanol facilities

Company	Site	Feed	Year	ML/yr	Type	Status
Abengoa	ES	Ag. res. MSW	2008	5	Demo	Idle
Beta Renew.	IT	Ag. resid.	2013	76	1st ind.	Idle
Energochemic	SL	Ag. resid.	2017	70	Comm	Constr.
CIMV	FR	Ag. resid.	2017	0.9	Demo	Com.
Clariant	DE	Ag. resid.	2012	1.2	Demo	Op.
DuPont	USA	Ag. resid.	2016	114	1st ind.	Idle
Granbio	BR	Bagasse	2014	82	1st ind.	Com.
Futurol (pre-treatment)	FR	Ag. resid.	2011 2016	0.18	Demo Demo	Op. Op.
Inbicon (Ørsted)	DK	Straw	2010	6	Demo	Idle
POET /DSM	USA	Ag. resid.	2014	76	1st ind.	Com.
Raizen	BR	Bagasse	2015	40	1st ind.	Com.
Borregaard BALI	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	1st Ind.	Op. ?

Developments lignocellulosic ethanol

CLARIANT

Announced plans for plants in SL, RO.
See SPM presentation

Inbicon 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 .

Capacity 10 million liters ethanol from saw mill dust (pine)
Commissioning 2017

Cellunolix® Kajaani, Finland

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

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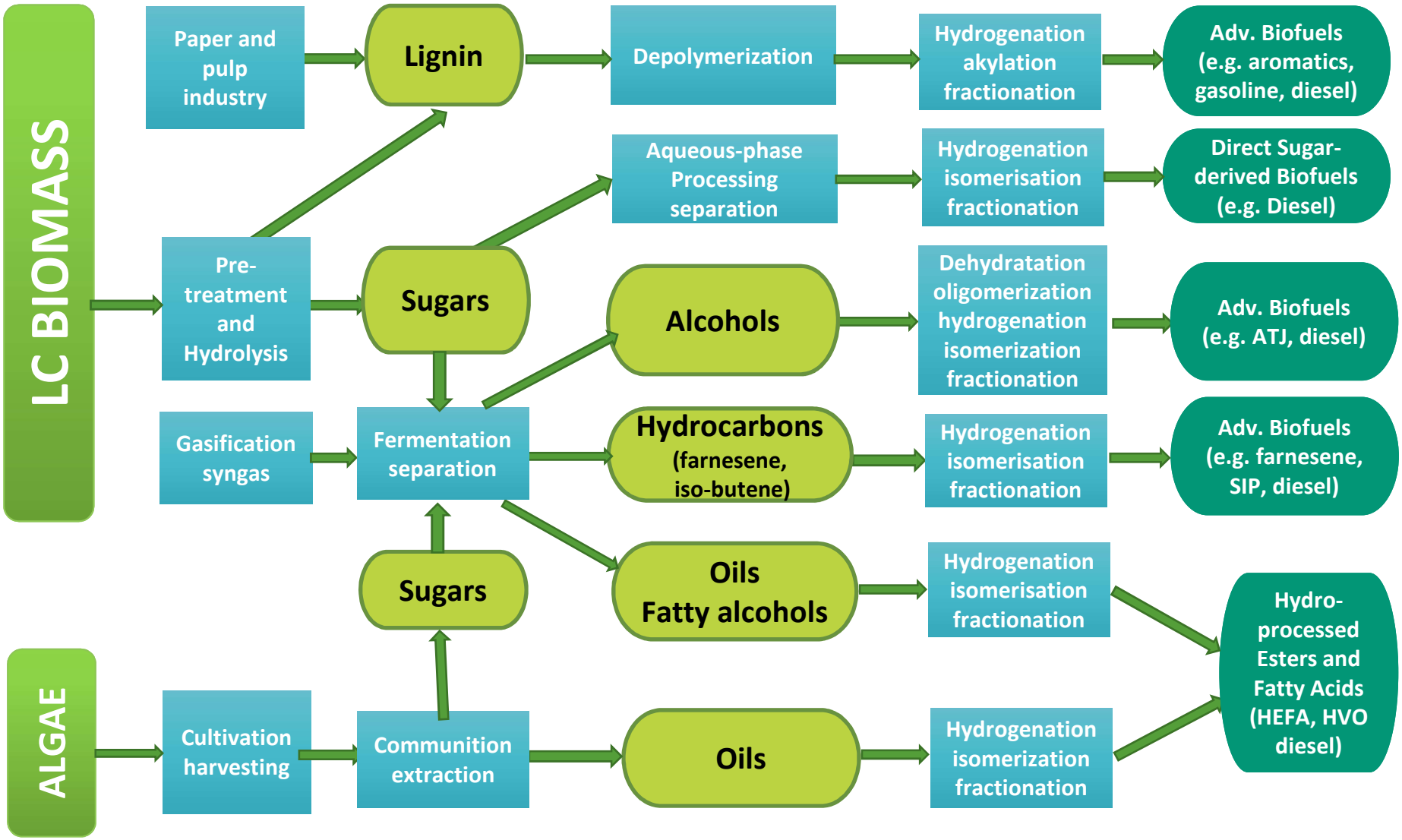
Intermediates to hydrocarbons



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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	1st ind.	Op.
BUTAMAX	UK USA	Iso-butanol	2012	0.2	Demo 1st ind.	Com. Plan.
GEVO	USA	Iso-butanol	2014	6	1st ind.	Com.
Global Bioenergies	FR	Iso-butene	2017	100 tpa	Demo	Op.
REGI (LS9)	USA	Fatty alchols	2012	0.13	Demo	Op.
VIRENT	USA	Various fuel/ non-fuel	2009 2013	~ 0.04 ~ 0.02	Demo Demo	Op. Op.
Syngas (CO+H2) to alcohol						
Lanzatech	USA	Ethanol Fatty alcohols	2018	60	Demo Dev.	Constr.

Alcohols to hydrocarbons

Company	Site	Feed	Year	Cap. ML/yr	Type	Status
Main product diesel and jet						
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.
Main product gasoline						
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				

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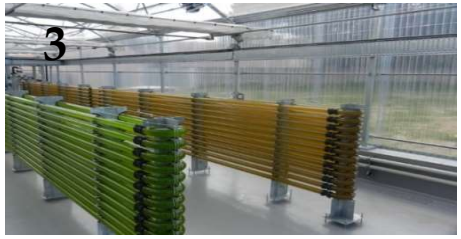
Microalgae – Demo Plants

	Company		Year	Type	Cap. kton dw/y	Product	Future
1	InteSusAl	PT	2015	Microalgae	0.04	Biodiesel	Non-fuel
2	All-Gas	ES	2014	Microalgae	0.014	Biogas	Fuels
3	Algafuel	PT	2014	GE µ-algae	0.001	Ethanol	HTL-oil, non-fuel
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

HYDROGEN

ITM POWER
Energy Storage | Clean Fuel

0.2-10 MWE

BUTANOL

EVONIK INDUSTRIES

RHETICUS R&D PROJECT

2018-2020

METHANOL

CARBON RECYCLING INTERNATIONAL

4 000 TPA PLANT

AMMONIA

VATTENFALL

FEASIBILITY STUDY

FT DIESEL

sunfire

150 KWE/ 130 LITER/DAY

METHANE

Audi

*3*2 MWE*

FORMIC ACID

TEAM FAST

R&D PROJECT TU/e

GASOLINE

GLOBAL BIOENERGIES

PILOT 100 TPA ISOBUTENE

*2*ISOBUTENE +H2=ISOOCTANE*

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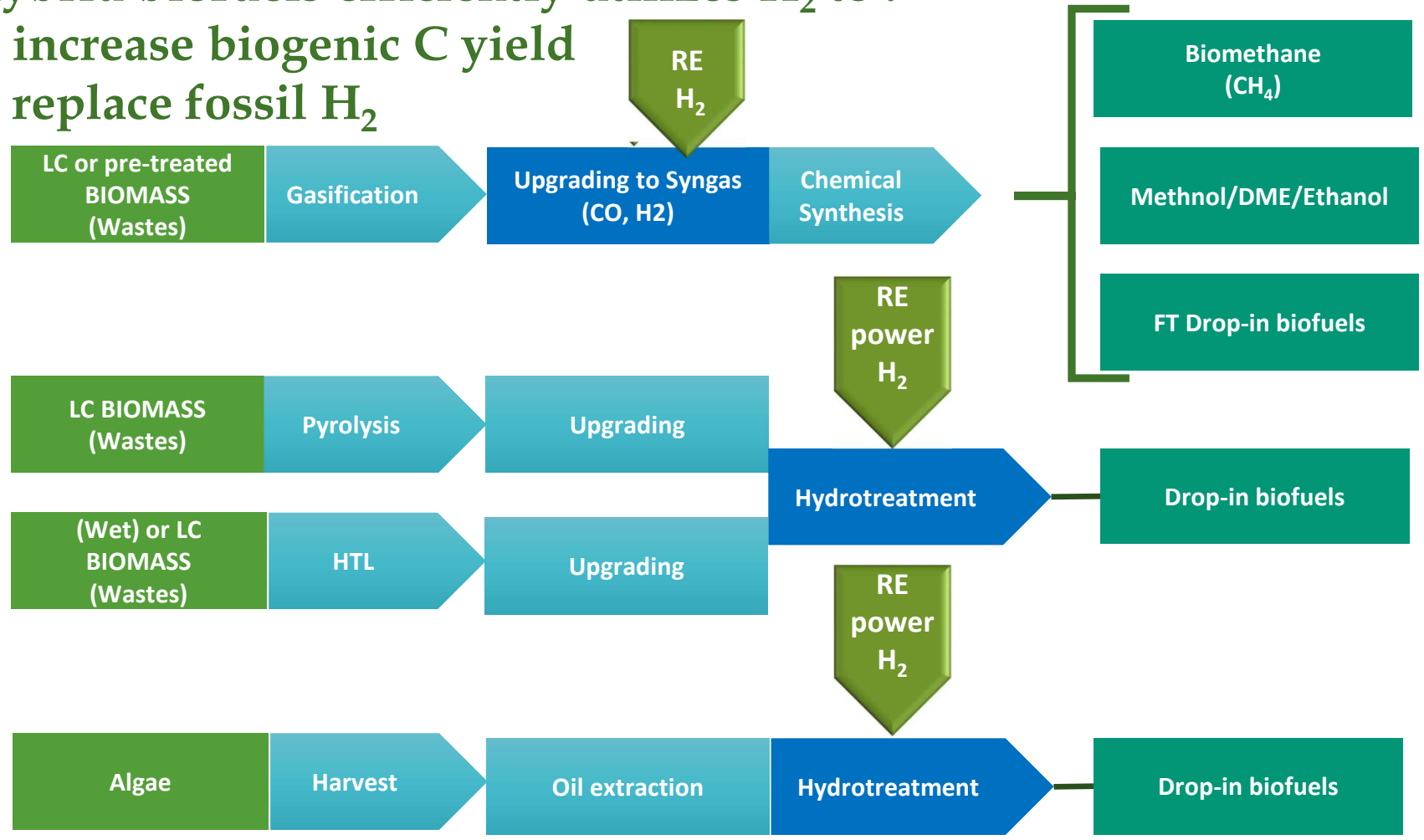
Power-to-biofuels

Hybrid biofuels efficiently utilizes H_2 to :

- ✓ increase biogenic C yield
- ✓ replace fossil H_2



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Suming up and take-away messsages

- R&D institutions mentioned VTT, Fraunhofer, KIT GTI, ECN, LNEG,LTU, Univ. Twente, Univ. Sheerbroke, TUW, AAU etc. algae R&D places and others not mentioned.
- Spin-offs BTG, Susteen, Repotec, Enerkem, algae companies, Phoenix Biopower,, Ensyn etc.
- Major industrials, Andritz,Clariant , M&G,, Valmet etc.
- Industrial implementation of R&D requires patience.
- The economics of bridging the "development gap" to operational 1st 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.
- Also policy must be sustainable over time, not only biofuels

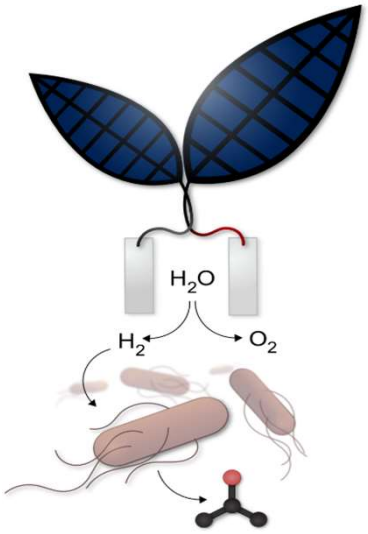
Suming up and take-away messsages

- **Industrial implementation of R&D requires patience.**
- **The economics of bridging the "development gap" to operational 1st 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.**
- **Also policy must be sustainable over time, not only biofuels**

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_2 and H_2O into oxygen and chemical energy, e.g. fuel molecules.

Source CleanTecnica 2017-08-22