Bio-LNG liquefaction technology: Overview and recent developments

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What do we mean by BioLNG?

Bio LNG = Bio Liquid Natural Gas

- Direct production biogas : **Liquid Bio Methane (LBM)**
- Undirect, from grid gas: **LNG + certificate of origin or guarantee of origin**

BioLNG: a (very) dense biogas

1 Olympic swimming pool full of Biogas
(Equivalent Volume of about 500 m3)

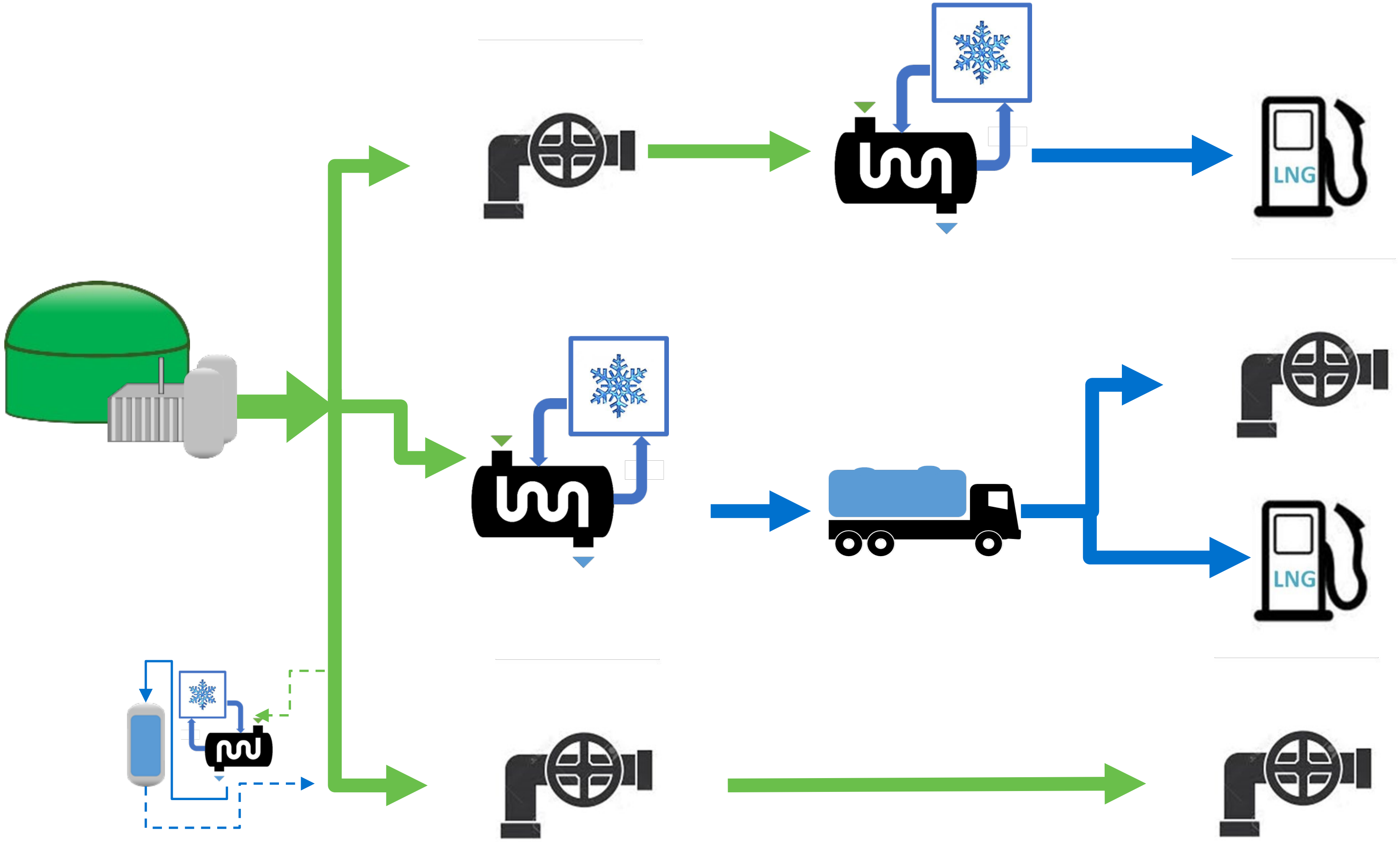
T= 30° C
P ≈ 1,05 bar_a

=

2 Bathrooms of BioGNL
(Equivalent Volume of about 480 L)

T= -160° C
P ≈ 1,02 bar_a

Which BioLNG applications?



Grid Gas Liquefaction with Green certificate (or Guarantee of origin) for biofuel production

« Virtual pipe »

Direct biofuel production

Small Peak shaving of local grid (e.g.: Azola system [11])

Worldwide view of BioLNG activity by 2021

Plant /Project name	Application	Country	Biogas feed rate (Nm3/h)
Ege BIOGAS, Nes, Oslo	?	Norway	1000
Methabraye	Virtual pipe	France	260
Troia, Foggia - Store&Go project	Biofuel	Italy	100
Greenville Energy	Virtual pipe	UK, Northern Ireland	290
VEAS, Asken	?	Norway	?
Tekniska verken Linköping	?	Sweden	?
Godorf	Biofuel: Grid gas liquefaction with certificate	Germany	15000
Stord Island	Biofuel	Norway	750
Cooperativa Speranza, Candiolo (TO)	Project	Italy	530
Altamont Landfill	Biofuel	USA	2400
Lidköping	Biofuel	Sweden	1200
Wijster (Drenthe)	Uncertain	Netherlands	870
Rivière-du-Loup	Uncertain	Canada	750
Plainval	LBM Peak-shaving	France	?

Operationnal
Project/under construction
Unknown status

LBM Vs « standard » LNG

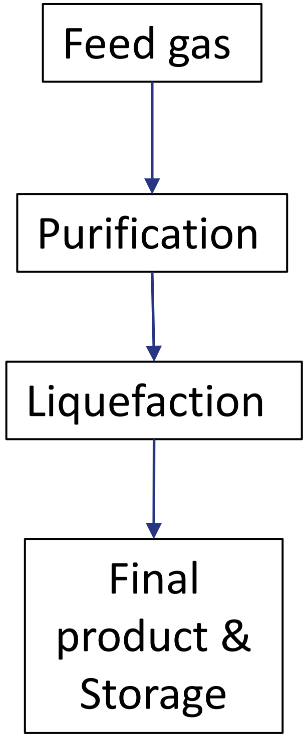
LBM

Low inlet biogas pressure (≈ 0,1 barg)
Small biogas flow rate (< 1000 Nm3/h)

Biogas CO_2 content > 35%mol

Low efficiency compressors

Possibly stored over 14 barg (depends on application)
O_2 content possibly > 0,2%mol
N_2 content possibly > 0,8 %mol
No C2+ contents: almost pure CH_4 at 99%mol



« Standard » LNG

High inlet pressure (> 40 barg)
High feed flow rate (> 500 000 Nm3/h)

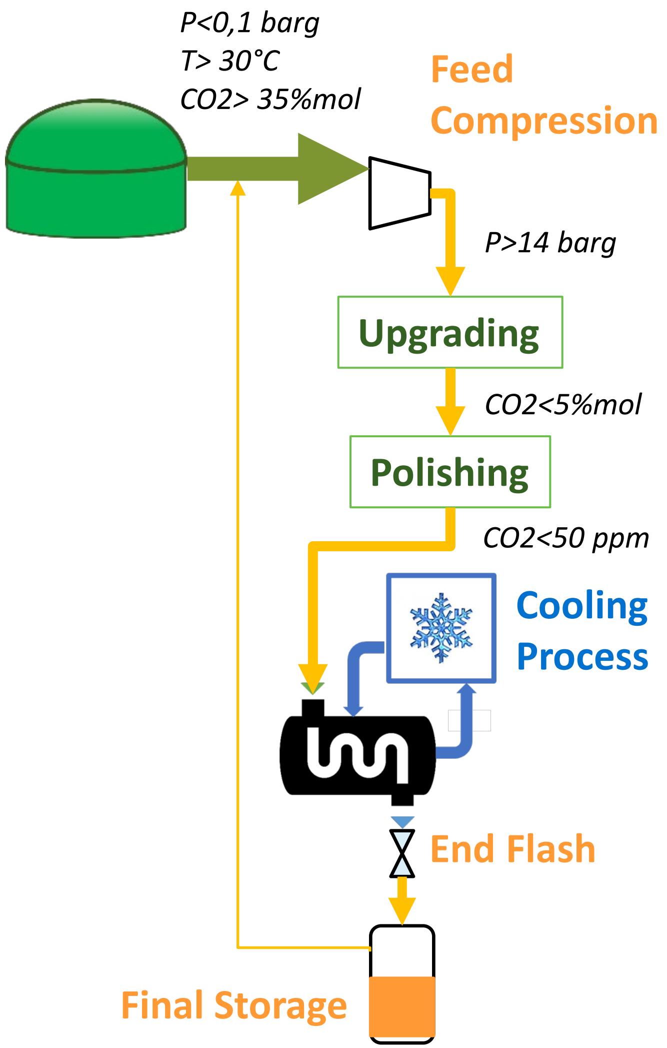
Medium feed CO_2 content > 20%mol

High efficiency compressors

Stored at low pressure (< 0,2 barg)
Low N_2 content possibly
C2+ contents may be higher than 10%mol

BioLNG Liquefaction may need (at least) **twice more energy** than « standard » liquefaction for the same production flow: (average) > 1 $kWhe/kg_{LBM}$

Green gas liquefaction process: key technical features



FEED-GAS MANAGEMENT

- Level of feed compression
- Pressure of storage
- End-flash gas production

PURIFICATION PROCESSES

- Standard approach: Upgrading with either Membrane /water scrubbing / T-PSA / Amines scrubbing + polishing with T-PSA or specific technology
- Cryogenic purification:
  - With crystallization management
  - With specific distillation

COOLING PROCESS

- N_2 open cycle (very specific)
- Refrigerant phase change, often Mixed Refrigerant (MR)
- Vapor refrigerant:
  - Reverse Brayton cycle
  - Stirling cycle

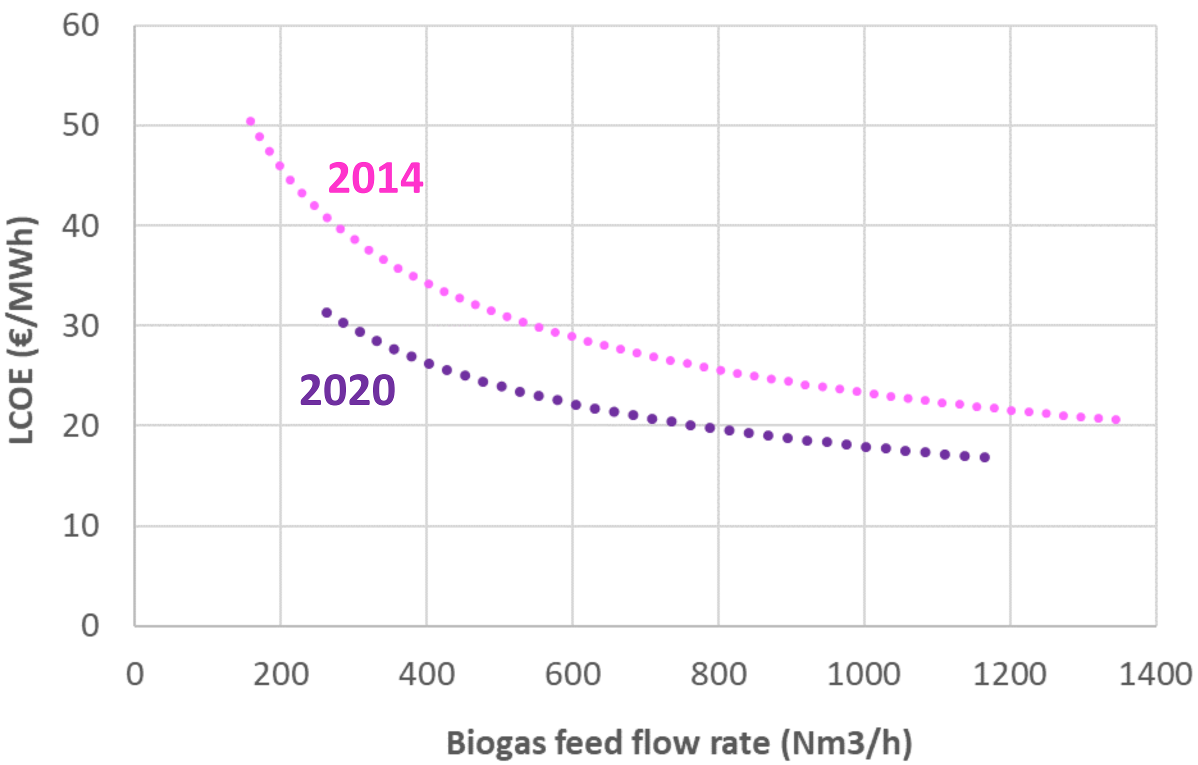
Illustration on some of the main BioLNG liquefaction technologies

BioLNG technology	Typical scale of application	Feed gas management	Purification processes	Cooling process	Ref
Wärtsila MR	Biofuel, virtual pipe, grid gas liq.; Biogas feed > 500 Nm3/h	Medium biogas compression	Not known	MR cycle	[1]
Stirling cryogenics-Hysytech	Biofuel, virtual pipe, grid gas liq.; Biogas feed > 40 Nm3/h	Medium biogas compression	Membrane + proprietary scrubbing Process	Stirling cycle	[2][3]
Cryopur	Biofuel, virtual pipe, grid gas liq.; Biogas feed > 250 Nm3/h	Medium biogas compression	Cryogenic purification	MR cycle	[4]
Galileo cryobox	Biofuel, virtual pipe, grid gas liq.; Biogas feed > 500 Nm3/h	Proprietary liq. process	Membrane + T-PSA	Prorietary liq. process	[5]
Air Liquide TBL-350	Biofuel, virtual pipe, grid gas liq.; Biogas feed > 800 Nm3/h	Medium biogas compression	Not known	Reverse Brayton cycle	[6]
Liqal MLU	Biofuel, virtual pipe, grid gas liq.; Biogas feed > 80 Nm3/h	High biogas compression	No specific purif. Techno.	Mild cooling cycle	[7][8]
SIAD smart LNG	Biofuel, virtual pipe, grid gas liq.	Medium biogas compression	No specific purif. Techno.	Reverse Brayton cycle and N2-open cycle	[9]
AzolaBIO and GRID	LBM peak-shaving	No compression (feed is biomethane injection stream)	Proprietary polishing process	N2-open cycle	[11]

Rough orders of magnitude for purification and liquefaction cost of biogas

LCOE : Leveraged Cost of energy

Error Margin: 35%



Scale effect: doubling the size may reduce by more 30% the global cost

« Time » effect: within the last past 6 years, global cost almost dropped by 25%

By 2014: 9 BioLNG process providers identified

By 2020: 15 BioLNG process providers identified

Main technical challenges for future BioLNG

- **Polishing stage**: so far, only a few technology providers
- Need for a better **standardization of the liquefaction process technology**
- **Pressure storage optimization** for future logistic BioLNG chains: Liquefaction process may be significantly optimized by taking advantage of the higher level of pressure storage operability for small scale cryogenic tanks

ENGIE-Lab polishing test rig

ENGIE-Lab bioLNG pilote plant

THANK YOU FOR YOUR ATTENTION!

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References

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APPENDIX

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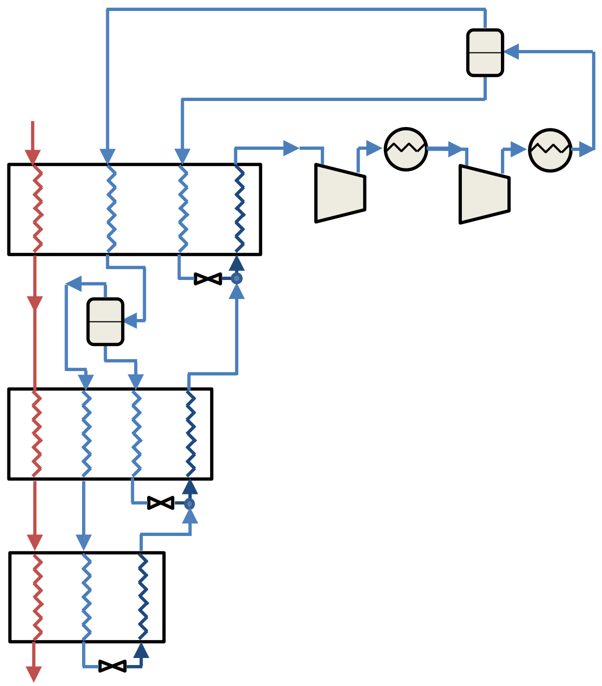
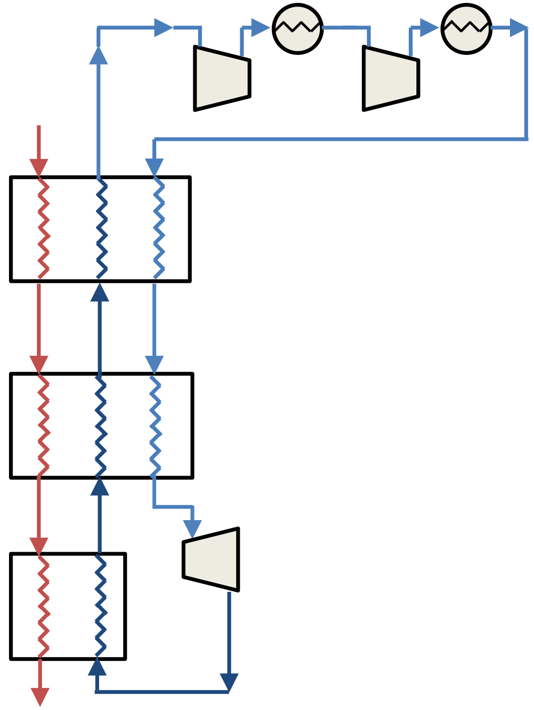
Liquefaction process: MR cycles and Brayton inverse cycle





MR cycle (refrigerant phase change):
- More efficient
- Less flexible, more sensitive

Reverse Brayton cycle (refrigerant always vapor) :
- Less efficient
- More robust and flexible

Stirling cycle for refrigeration

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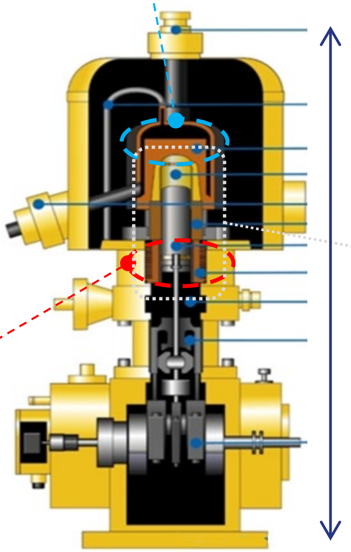
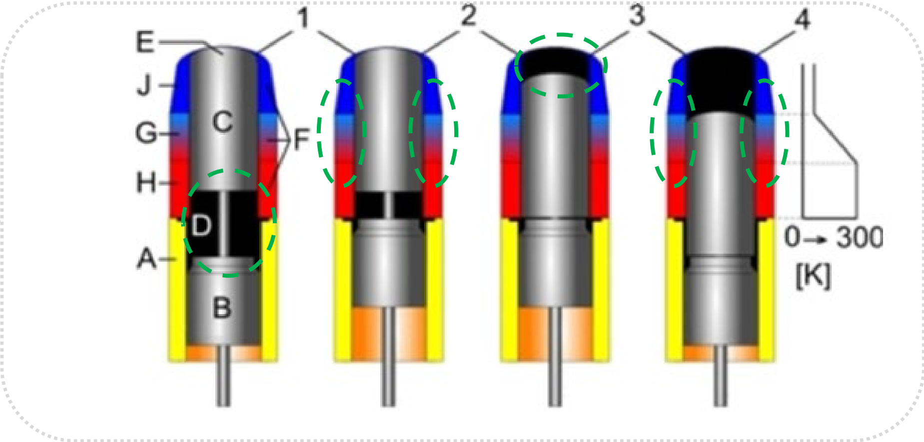
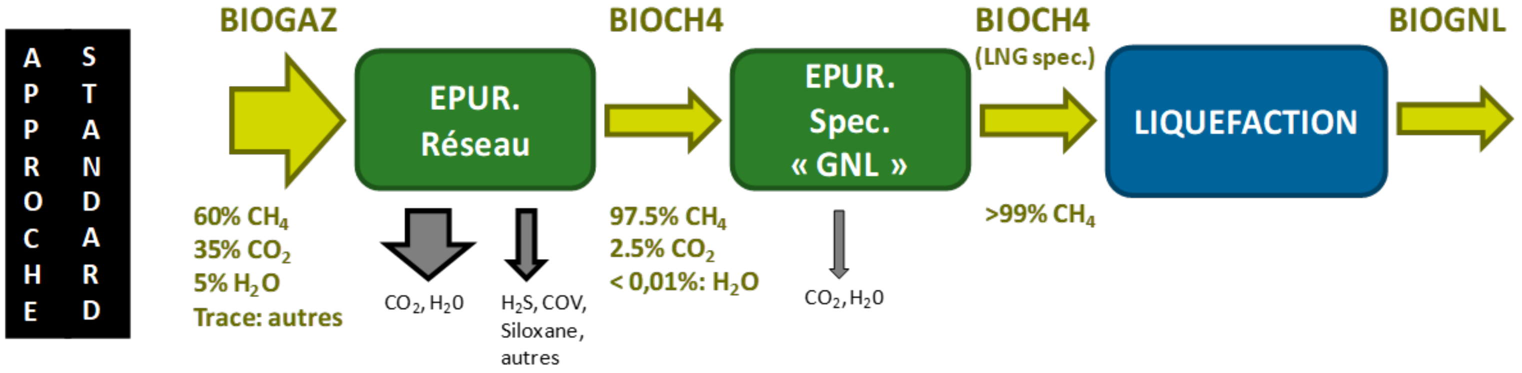


StirLNG-1: Liquefaction of ≈ 10 à 30 Nm3/h biomethane

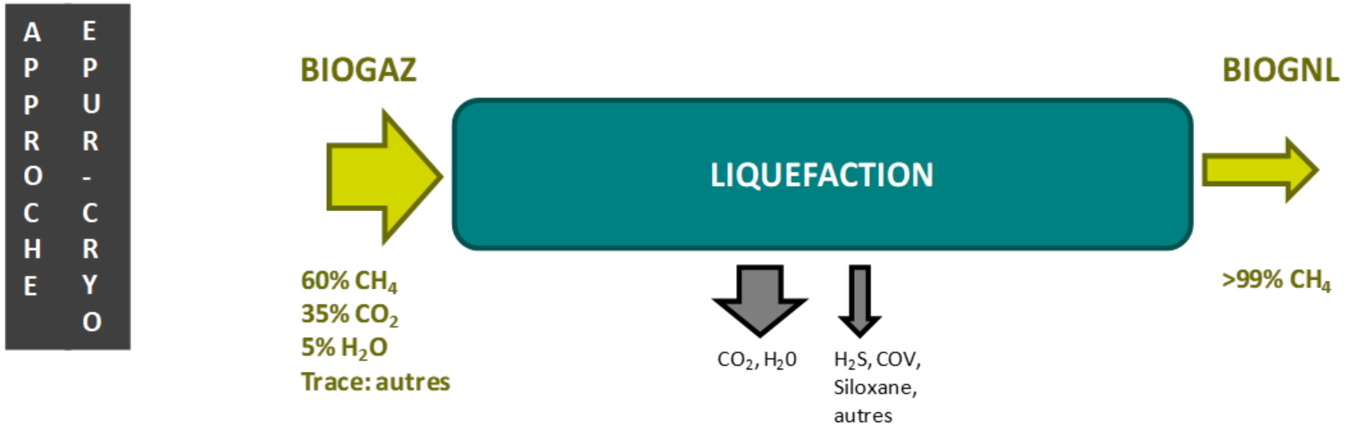


Ref: Stirling cryogenics [12]

Standard vs cryogenic purification



First Purification and only then liquefaction of a purified feed stream without any risk of cristallization



Purification and cooling-liquefaction are both achieved at same time: Impurities cristallization is promoted and controled