



# Cryo Pur

From waste to fuel

## TRANSFORMING BIOGAS INTO BIO-LNG AND LIQUID CO<sub>2</sub>







# About Cryo Pur

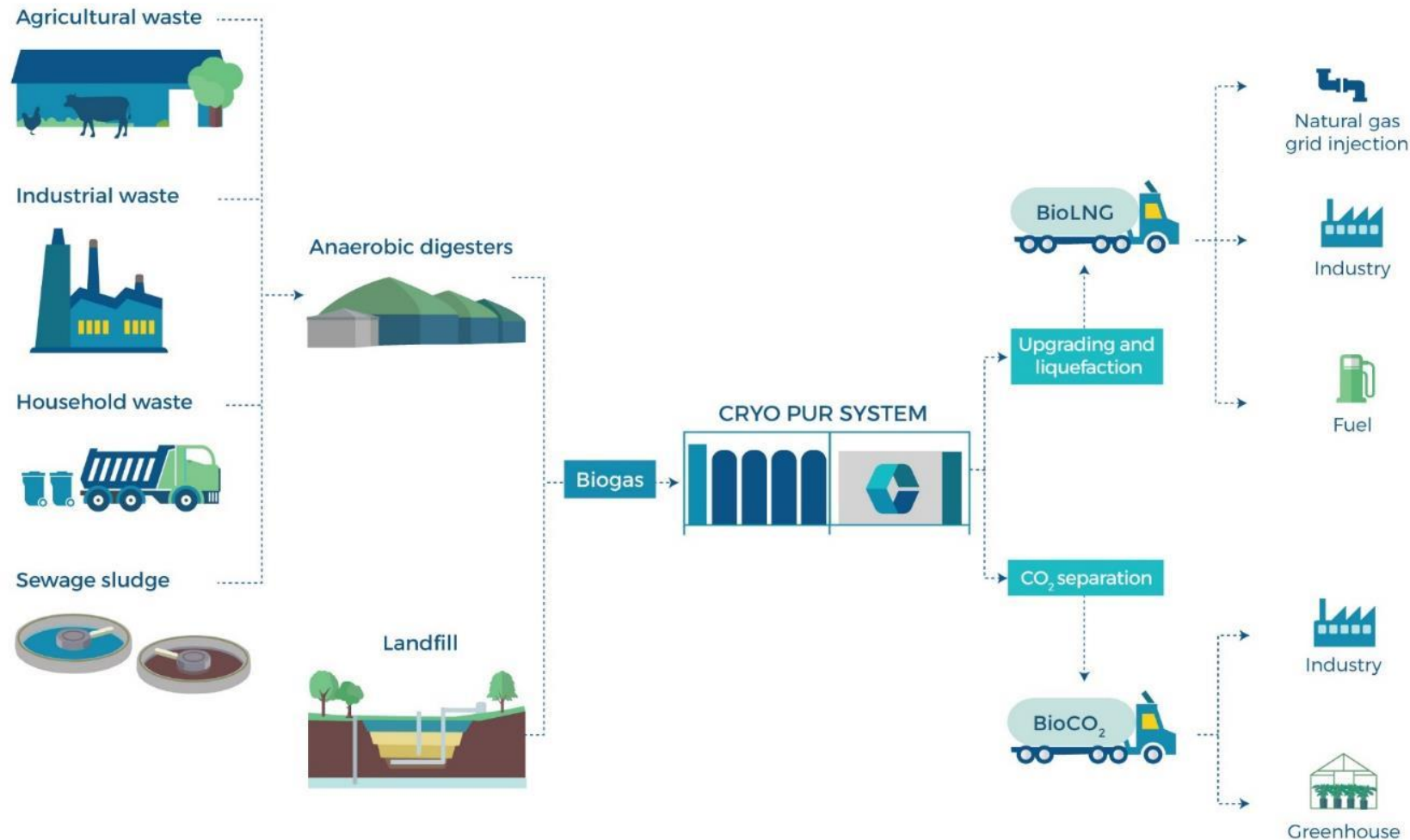
*The expert in cryogenic biogas upgrading and liquefaction*

- **Activity** : Supply, installation and maintenance of industrial equipment for the production of liquid biomethane (bio-LNG) and liquid CO<sub>2</sub>.
- **History:**
  - 15 years R&D in the field of cryogenic CO<sub>2</sub> capture.
  - Pilot and demonstration project at a WWTP in France (2015-2017).
  - First commercial unit commissioned in Northern Ireland (10/2017).
  - 3 tenders won in France and Italy.
- **Intellectual Property** : 7 international patents.
- **Team** : 28 people, including 20 PhD, engineers and technicians.
- **Facilities** : Head Office and workshop in Palaiseau, France (Paris area).
- **Equity raised** : € 3 m in 2015, € 6 m in 2017.





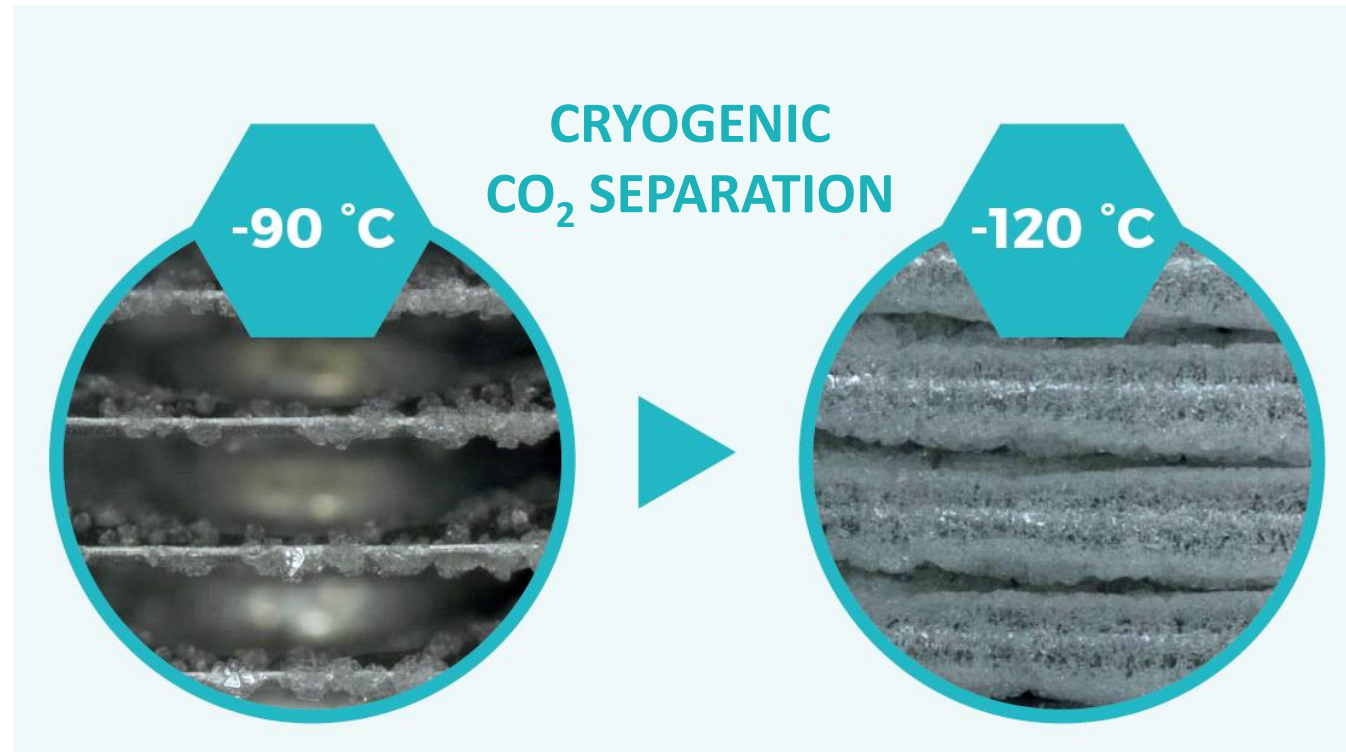
# Offering new solutions to the biogas sector



- **Bio-LNG** is a **sustainable fuel for trucks**, that reduces GHG, NO<sub>x</sub> and particle emissions vs. diesel.
- **Bio-LNG** is stored and transported easily, which enables biomethane projects even **when the gas grid is remote or has a limited capacity**.
- **Liquid Bio-CO<sub>2</sub>** is an interesting by-product **that can be used in various applications**: greenhouses, refrigeration in transport, chemical industry...

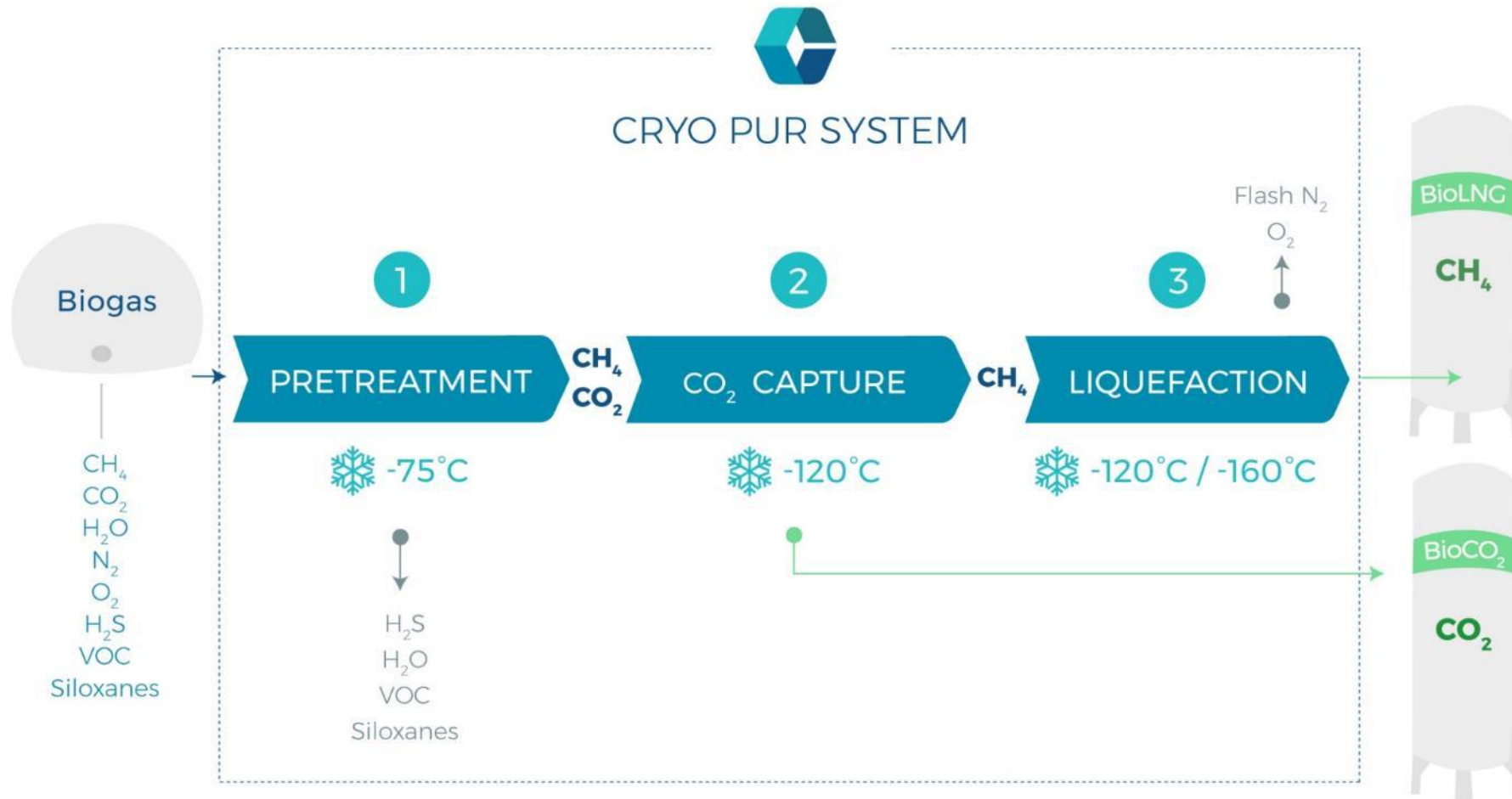


# Cryo Pur Process (1 | 3)



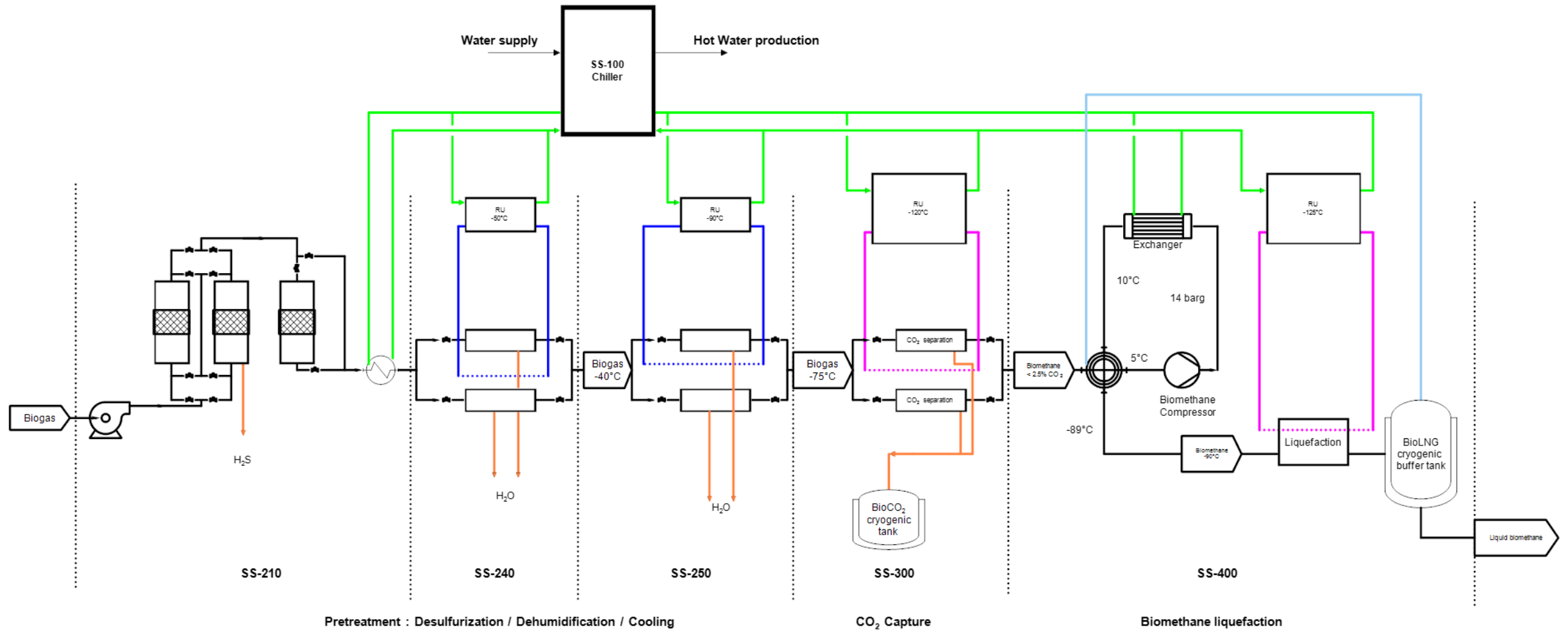


# Cryo Pur Process (2|3)





# Cryo Pur Process (3|3)





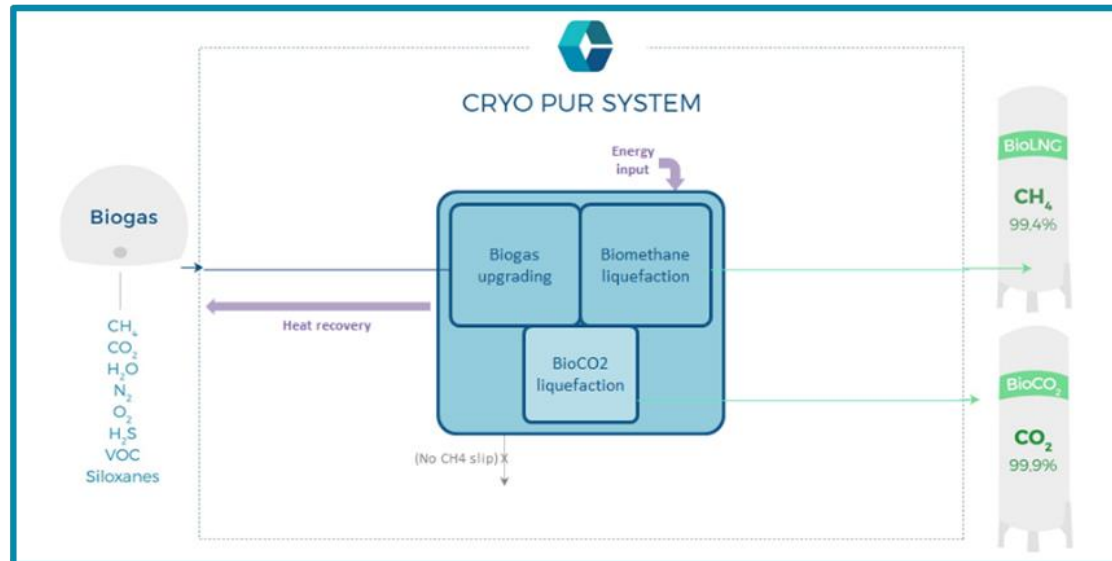
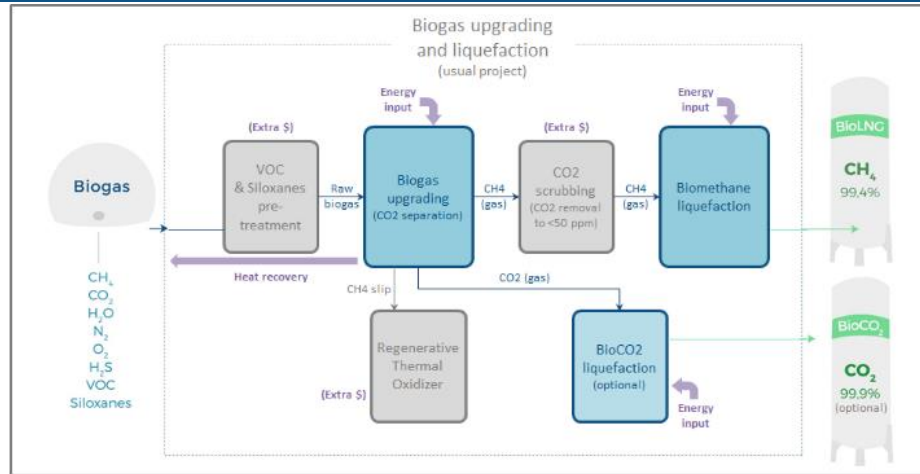
# Cryo Pur technology benefits (1 | 2)

- **Integrated technology** for biogas upgrading, bio-CO<sub>2</sub> liquefaction and biomethane liquefaction
  - Cost efficiency
  - Simplified integration and management of interfaces
  - Performance guarantees
  - Large product range
  - Liquid CO<sub>2</sub> as by-product
- **Low electric energy consumption** :
  - 0.6 kWh/Nm<sup>3</sup> raw biogas for both upgrading and liquefaction: 14 barg/-120°C
  - 0.7 kWh/Nm<sup>3</sup> raw biogas for both upgrading and liquefaction: 1 barg/-160°C
- **Heat recovery** on refrigeration systems covering up to 100% AD heating needs
- **No methane slip** or minimum methane slip for landfill biogas
- **High flexibility** of the system: from 50% to 120% of the nominal biogas flowrate
- Physical separation, **no consumables** except activated carbon

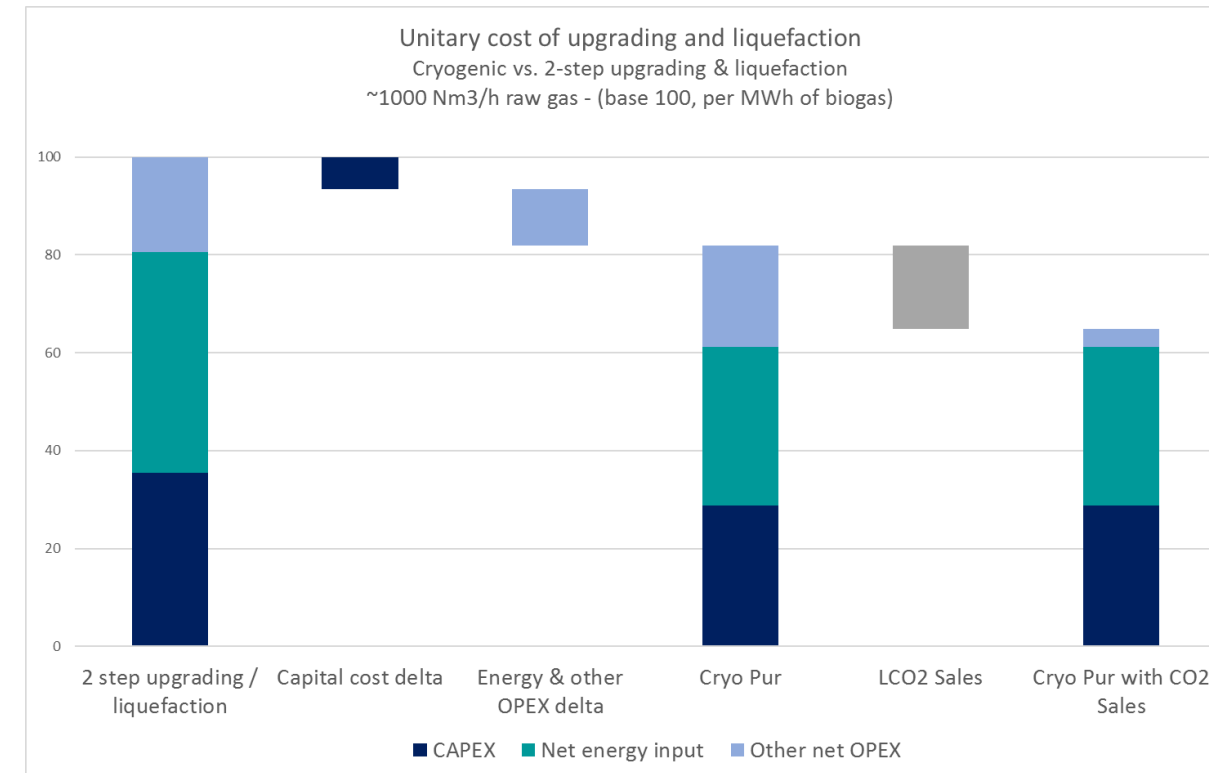




# Cryo Pur technology benefits (2|2)



=> Better economics for large-scale bio-LNG projects :



=> Enables small-scale bio-LNG projects.





# Reference #1 : BioGNVal Project (1|5)

## Valenton WWTP, France (120 Nm<sup>3</sup>/h biogas)





# Reference #1 : BioGNVal Project (2|5)

## Demonstration project profile

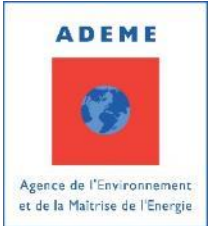
- **Site location:** WWTP rue Louis Armand, Valenton, France (Paris Area).
- **Biogas source:** Sewage sludge.
- **Biogas composition:** CH<sub>4</sub> 60%, CO<sub>2</sub> 39%, H<sub>2</sub>S 100 ppm, Siloxanes, VOCs.
- **Project period:** October 2015 - April 2017.
- **Capacity:**
  - **Raw biogas flow:** 120 Nm<sup>3</sup>/h biogas.
  - **Bio-LNG prod.:** 1 tpd.
  - **Liquid CO<sub>2</sub> prod.:** 1.6 tpd.





# Reference #1 : BioGNVal Project (3|5)

## Demonstration project partners



Finance  
Technical expertise



Design, manufacturing, operation  
of the demonstration plant for  
bio-LNG and bio-CO<sub>2</sub> production



Owner of Valenton WWTP



LNG/bio-LNG fueling  
station provider



Operator of Valenton  
WWTP and Project coordinator



LNG/bio-LNG truck  
provider



Liquid CO<sub>2</sub> refrigeration  
system provider





# Reference #1 : BioGNVal Project (4|5)

## Key achievements

**Bio-LNG transfer to the mobile transport station**



Following demo plant assessment:  
Cryo Pur system is eligible to receiving support  
from ADEME as a proven technology

**Use as vehicle fuel**



**Use as industrial fuel**



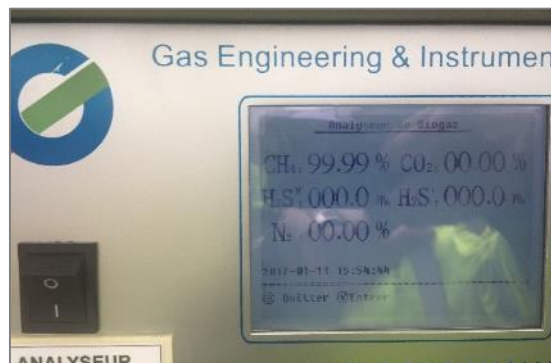


# Reference #1 : BioGNVal Project (5|5)

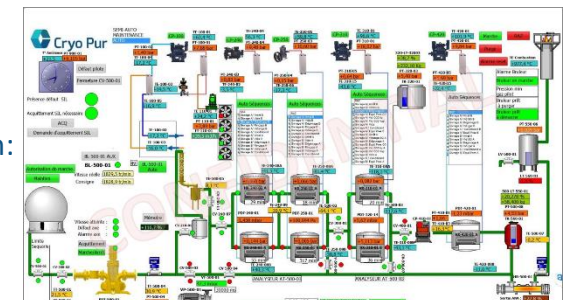
## Performance validation

- **Pilot phase:** (10/15-04/16)
  - Validation of Cryo Pur process.
  - Safe operation on Seveso site.
  - Validation of pre-treatment efficiency.
  - Validation of product specifications:
    - 99.7% pure bio-LNG product @ 14 bar(g).
    - 99.99% pure liquid CO<sub>2</sub> product.
  - Key learnings including improvements on H<sub>2</sub>S removal process and compressor redundancy.
- **Demonstration phase:** (12/16-04/17)
  - 24/7 operation during 17 weeks.
  - Automation and remote monitoring system.
  - Validation of system performances.
  - Bio-LNG product @ 4 - 14 bar(g).
  - Key learnings including improvements on valve design and plant layout.
  - Following demo plant assessment:  
Cryo Pur system is eligible to receiving support from ADEME as a proven technology.

Online gas analysis:



Automated control screen:





# Reference #2 : Greenville Project (1|5)

## Northern Ireland (300 Nm<sup>3</sup>/h biogas)

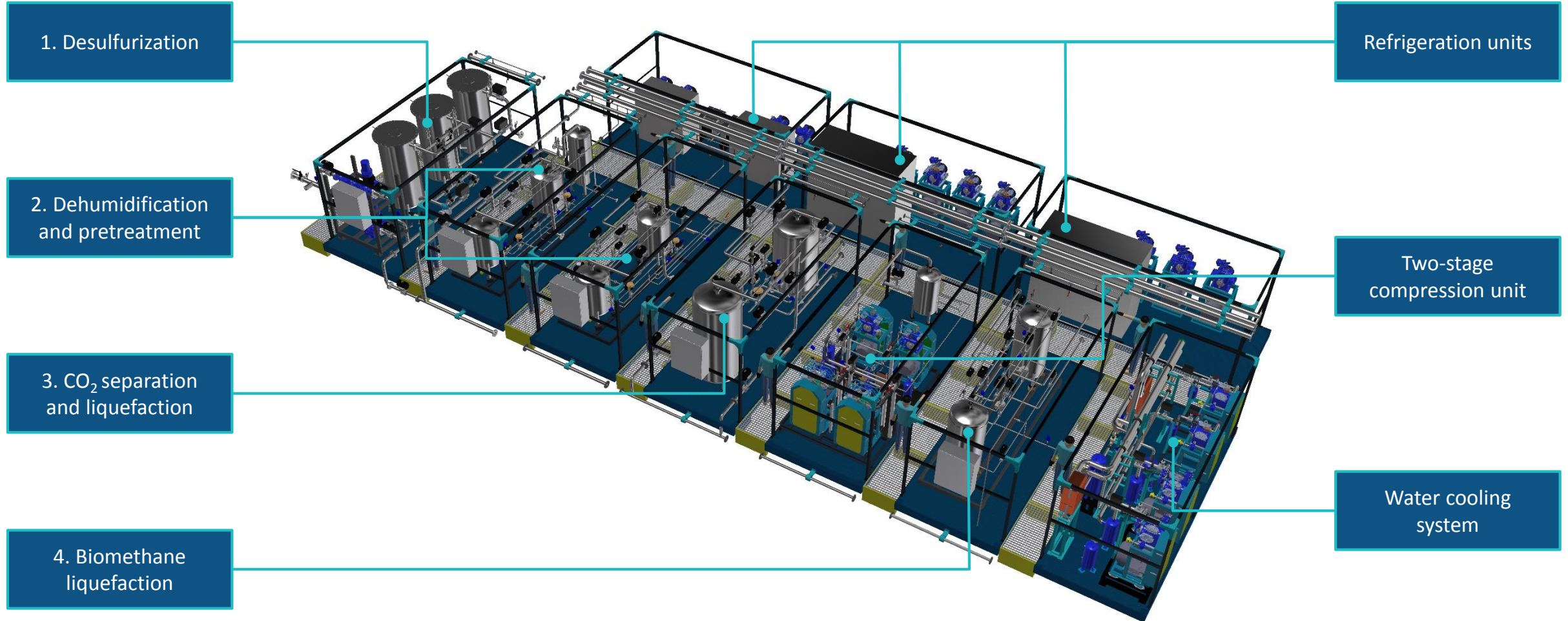






# Reference #2 : Greenville Project (2|5)

## Layout of the industrial unit







# Reference #2 : Greenville Project (3 | 5)

## Equipment delivery







# Reference #2 : Greenville Project (4|5)

## Equipment installation







# Reference #2 : Greenville Project (5|5)

## Equipment installation

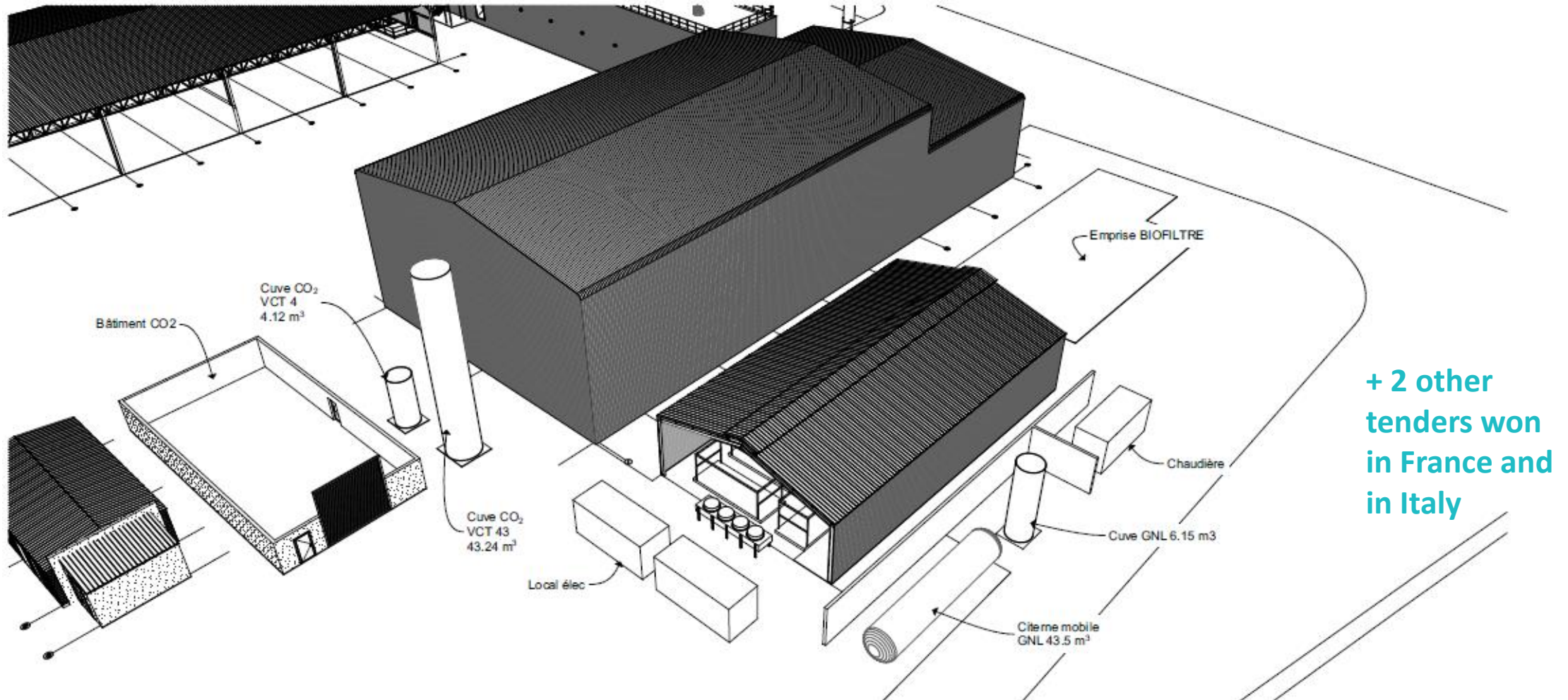






# Reference #3 : Confidential

## Angers, France (400 Nm<sup>3</sup>/h biogas) – 2018



+ 2 other  
tenders won  
in France and  
in Italy



# Conclusion

The first integrated system for biogas upgrading,  
biomethane liquefaction and liquid CO<sub>2</sub> production  
- Now commercial.

## Cryo Pur solutions :

<b>Cryo Fuel</b>	Production of bio-LNG fuel
<b>Cryo Dist</b>	Production of biomethane from landfill gas
<b>Cryo Haul</b>	Production of liquid biomethane for remote injection
<b>Cryo CO<sub>2</sub></b>	Production of gaseous biomethane and liquid bio-CO <sub>2</sub>

## Scope of supply :

- Integrated biogas transformation plant.
- Full service agreement incl. remote monitoring.
- Liquid gas storage / transfer station (option).

## Product range :

Product	Nominal biogas flow rate (Nm <sup>3</sup> /h)	Minimum biogas flow rate (Nm <sup>3</sup> /h)	Maximum biogas flow rate (Nm <sup>3</sup> /h)	Nominal bio-LNG production (t/d)	Nominal production of liquid CO <sub>2</sub> (t/d)
CP 70	70	35	85	0,7	1,3
CP 150	150	75	180	1,4	2,8
CP 250	250	125	300	2,3	4,7
CP 500	500	250	600	4,7	9,5
CP 800	800	400	960	7,5	15,2
CP 1000	1000	500	1200	9,3	19,0
CP 1500	1500	750	1800	14,0	28,4
CP 2000	2000	1000	2400	18,7	37,9

## Delivery schedule:

ACTIVITIES & MILESTONES	MONTHS											
	1	2	3	4	5	6	7	8	9	10	11	12
Entry into force of the contract	▲											
Engineering												
P&ID Delivery			▲									
Procurement												
Manufacturing												
Specific equipment manufacturing							▲					
Mechanical reception									▲			
Commissioning												
End of commissioning											▲	
Installation												
Documentation delivery												▲
Performance tests												▲





# Thank you for your attention!



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# Reference #1 : BioGNVal Project

## Incoming biogas specifications

### Raw biogas specifications – BioGNVal project:

	Min	Nominal	Max	Unit
Dry biogas flow rate	50	100	120	Nm <sup>3</sup> /h
Temperature	10	20	37	°C
Pressure	5	20	35	mbar(g)
Dew point	10	20	37	°C
Dry biogas composition	Min	Nominal	Max	Unit
CH <sub>4</sub>	60	63	70	% vol
CO <sub>2</sub>	30	35	40	% vol
N <sub>2</sub>		2 ± 0.1		% vol
O <sub>2</sub>		0.43 ± 0.05		% vol
H <sub>2</sub> S	10	30	150	ppm vol
NH <sub>3</sub>	-	-	-	ppm vol
VOC	-	4,8	-	mg/m <sup>3</sup>
Siloxanes	-	7	-	mg/m <sup>3</sup>
H <sub>2</sub>	46	65	79	ppm
CO	-	-	-	ppm vol



# Scope of supply

