

Challenging Case Studies of Adsorption-based Technologies for Biogas/Landfill Gas Upgrading and CCU

José Vale Machado, PhD Eng.
CEO
SYSADVANCE SA



RNG WORKS Technical Workshop & Trade Expo
Produced by the RNG COALITION
to educate, demonstrate & promote best industry practices.



SYSADVANCE

SHAPING THE FUTURE OF TECHNOLOGY





- **FOUNDED IN 2002**
- **HIGH SPECIALIZATION IN GAS SEPARATION PROCESSES**
- **EXTENSIVE EXPERIENCE IN SEVERAL SECTORS OF INDUSTRY**
- **COMPLETE SOLUTIONS (TURNKEY)**
- **WORLD LEADER IN PSA TECHNOLOGY**
- **MORE THAN 3000 PSA SYSTEMS SOLD WORLDWIDE**

GLOBAL PRESENCE



SYSADVANCE
is present in more than
40 countries.

GERRESHEIMER

GRUPO CABELTE

ETMA METAL PARTS

SCHAEFFLER



ReFood
pure bioenergy
Greener. Safer. Cheaper.



GENTHERM

gold energy

CIN



TORRE TOMBO

trustenergy

navarra grupo

TAYLOR'S PORT

CR&R environmental services

REFER



Orgaworld
Part of Shanks Group

GAS PETRONAS

PEPSICO

efacec

Arnarlax
BIO-NATURAL SALMON

GREENLANE BIOGAS

Valeo



YAZAKI

LATAM AIRLINES

Semardel
ENVIRONMENT SERVICE

DU PONT

SOLVAY

nemak

KEPAR ELECTRONICS

ZEISS



REPSOL

prio energy

TEXAS INSTRUMENTS

RESPOL
RESINAS, S.A.



sapa:



Johnson Controls

Pernod Ricard

LACTOGAL

SOGRAPE VINHOS

BASF
We create chemistry



TOTAL

VIGOR

GREENSHORE

SALVAT

aludium
premium aluminium

sovena

Amkor Technology

BUSINESS AREAS



INDUSTRIAL



MEDICAL



ENERGY



***INTEGRATED
SOLUTIONS***



PSA

VSA

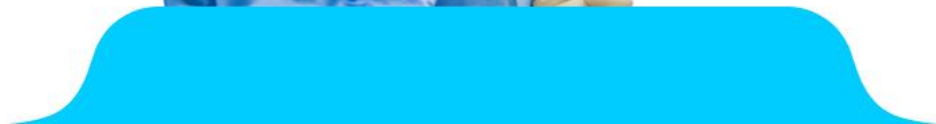


O₂
MED

AIR



VACUUM





ENERGY



CH₄



CO₂



O₂

BIO





CH₄

METHAGEN **AD**

Anaerobic Digestion

| BIOGAS UPGRADING

BIOGAS SOURCES AND APPLICATIONS | Pathways for profitability

MANY
BIOGAS SOURCES

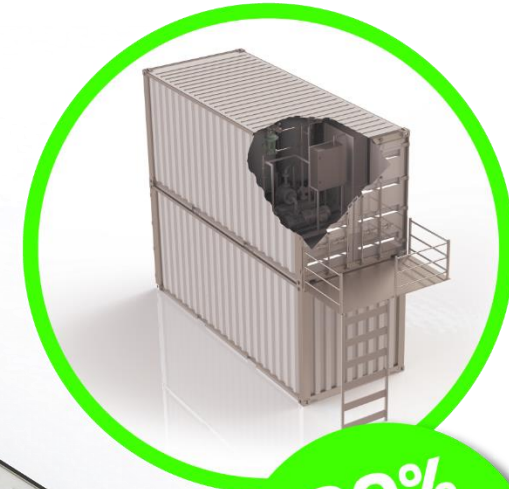


MANY
PATHS to PROFIT



METHAGEN^{AD}

METHABOOST



100%
CH₄
RECOVERY

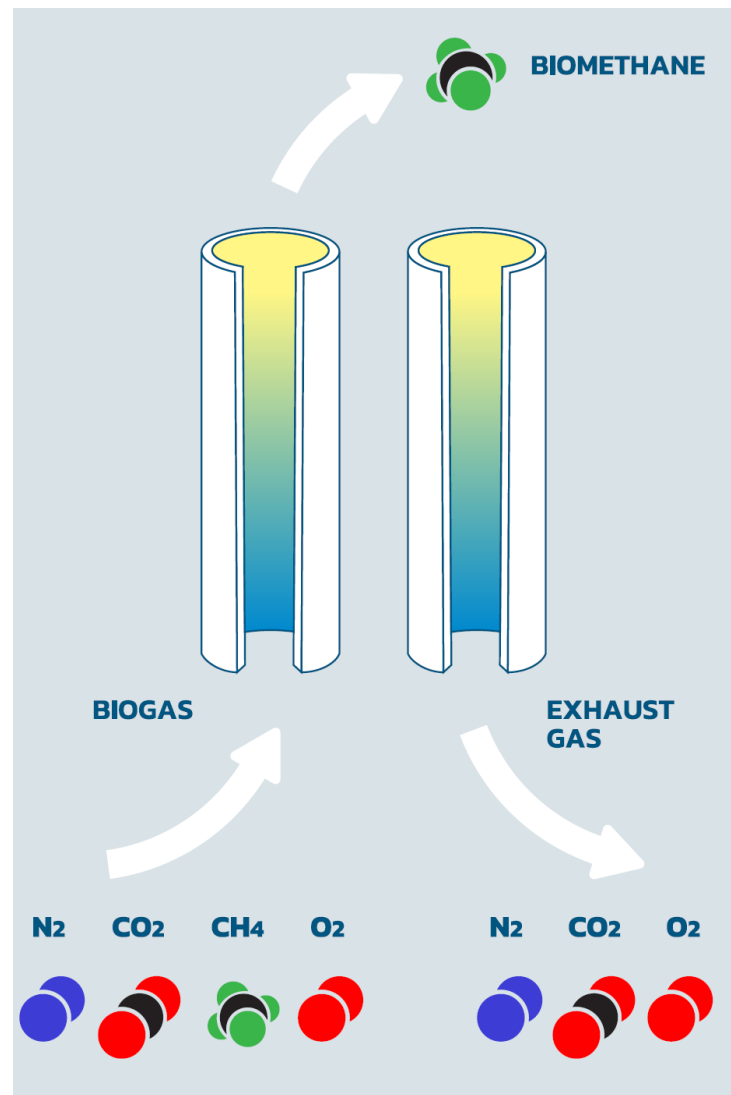


VPSA TECHNOLOGY

Range:

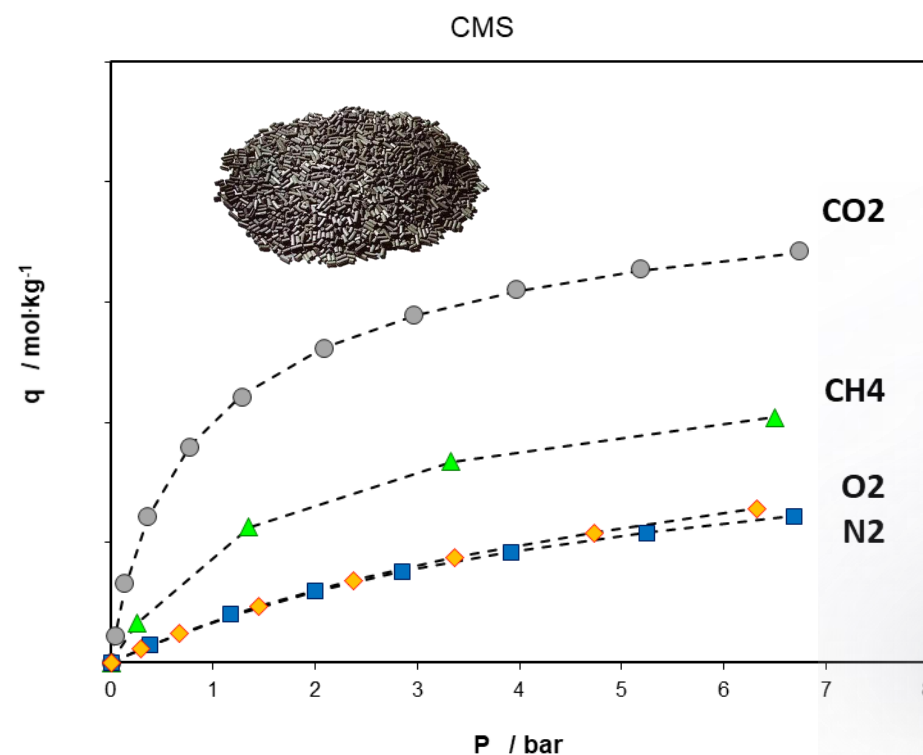
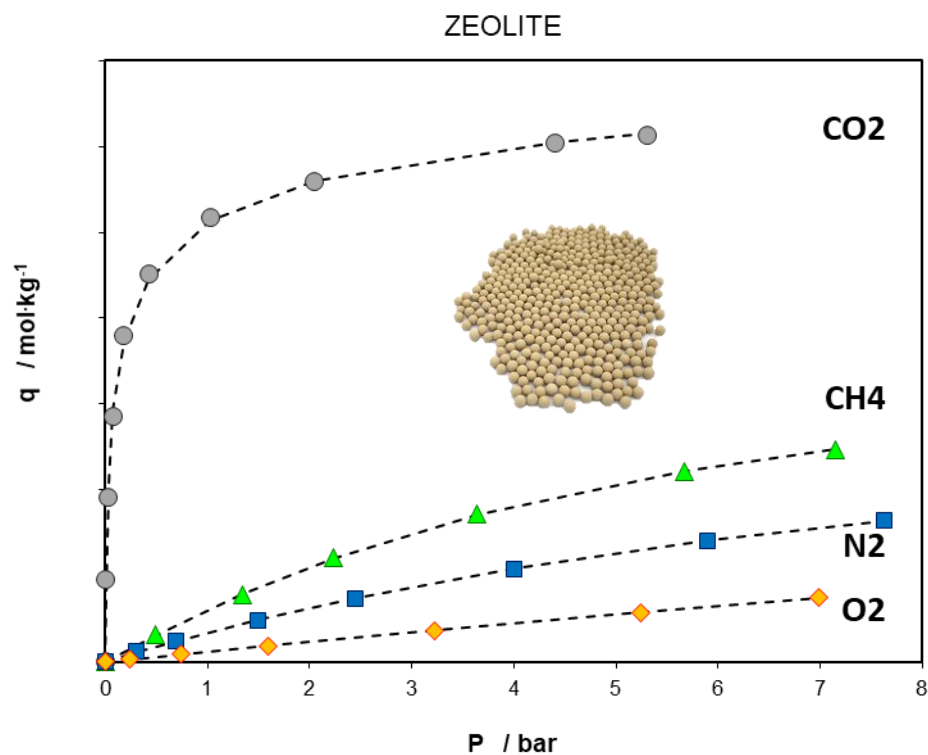
30 - 3000 SCFM

50 - 4800 Nm³/h



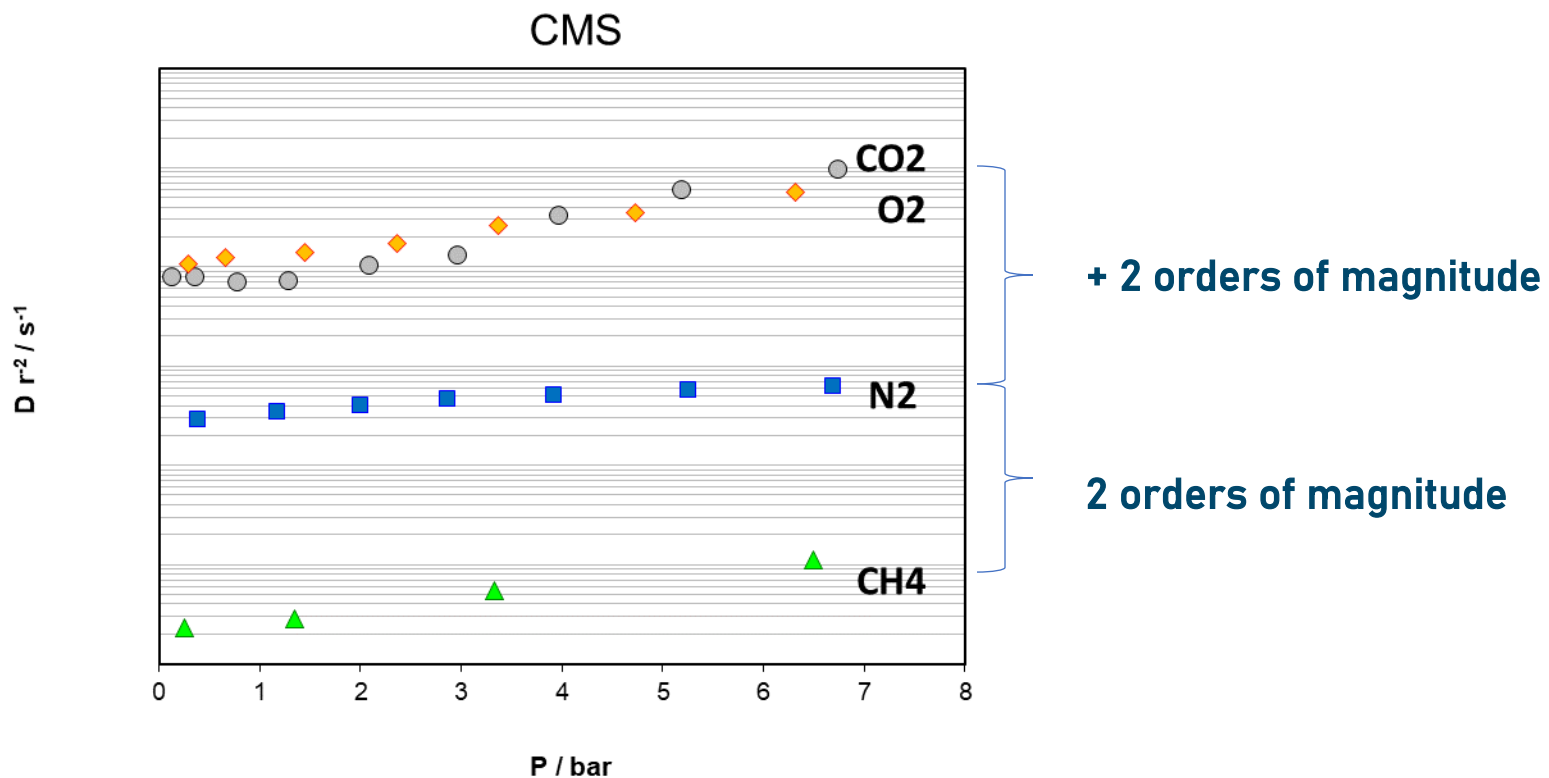
ZEOLITE MOLESIEVE vs. CARBON MOLESIEVE

EQUILIBRIUM SEPARATION



CARBON MOLSIEVE

KINETIC SEPARATION





- 100% CH₄ recovery > Zero emissions - METHABOOST option
- Lowest opex > 0.22 kWh/Nm³ of biogas
- Lowest capex
- High CH₄ purity > up to 99%
- High recovery > up to 99,96%
- Efficient O₂ and CO₂ removal
- N₂ reduction capability
- Dry process - no water or chemicals
- Non-cryogenic tech



- Water removal - Dewpoint < 50 ppmv H₂O
- High reliability/ high availability
- Simple installation & operation
- Small footprint
- Fast plant operational readiness
- Quick start & stop
- 4.0 Enabled > remote control & dynamic reporting
- Full turnkey upgrading solution
- CO₂ recovery option (CCU)

METHAGEN^{AD} | BIOGAS UPGRADING

Anaerobic Digestion



Single stage



plant for organic
waste digester



Mirandela, Portugal

Prémery, France

Tours, France



EUROPE

	Application	MODEL/RNG PROD CAP	BIOGAS SOURCE	KPI
	<p>Compressed RNG for NGV (PORTUGAL)</p> <p><i>Started 2016</i></p>	<p>METHAGEN XP1</p> <p>0.6 million Nm³/yr</p> <p>0.38 million SCF/yr</p>	<p>URBAN WASTE DIGESTER</p>	<p>< 0,42 kWh/Nm³ RNG</p> <p>< 0.66 kWh/SCF RNG</p> <p>> 98 % CH₄ Purity</p> <p>> 99 % CH₄ Recovery</p>
	<p>RNG for Grid Injection (FRANCE)</p> <p><i>2 Plants in 2020</i></p>	<p>METHAGEN XP3</p> <p>1.3 million Nm³/yr</p> <p>0.82 million SCF/yr</p>	<p>DAIRY/ FARMING DIGESTER</p>	<p>< 0,42 kWh/Nm³ RNG</p> <p>< 0.66 kWh/SCF RNG</p> <p>> 97 % CH₄ Purity</p> <p>> 99 % CH₄ Recovery</p>

METHAGEN^{AD} | BIOGAS UPGRADING

Anaerobic Digestion



Biogas from urban waste but with very stringent specs for NG grid

Perris, California - First injecting biomethane in the NG grid

1000 Nm³/h (650 SCFM) processing capacity and biomethane product meeting RULE30



In cooperation with:





CO₂ Purification for industrial application

1500 Nm³/h (950 SCFM) processing capacity and 98% CH₄ recovery with METHABOOST module



In cooperation with:



USA



GREENLANE
RENEWABLES™

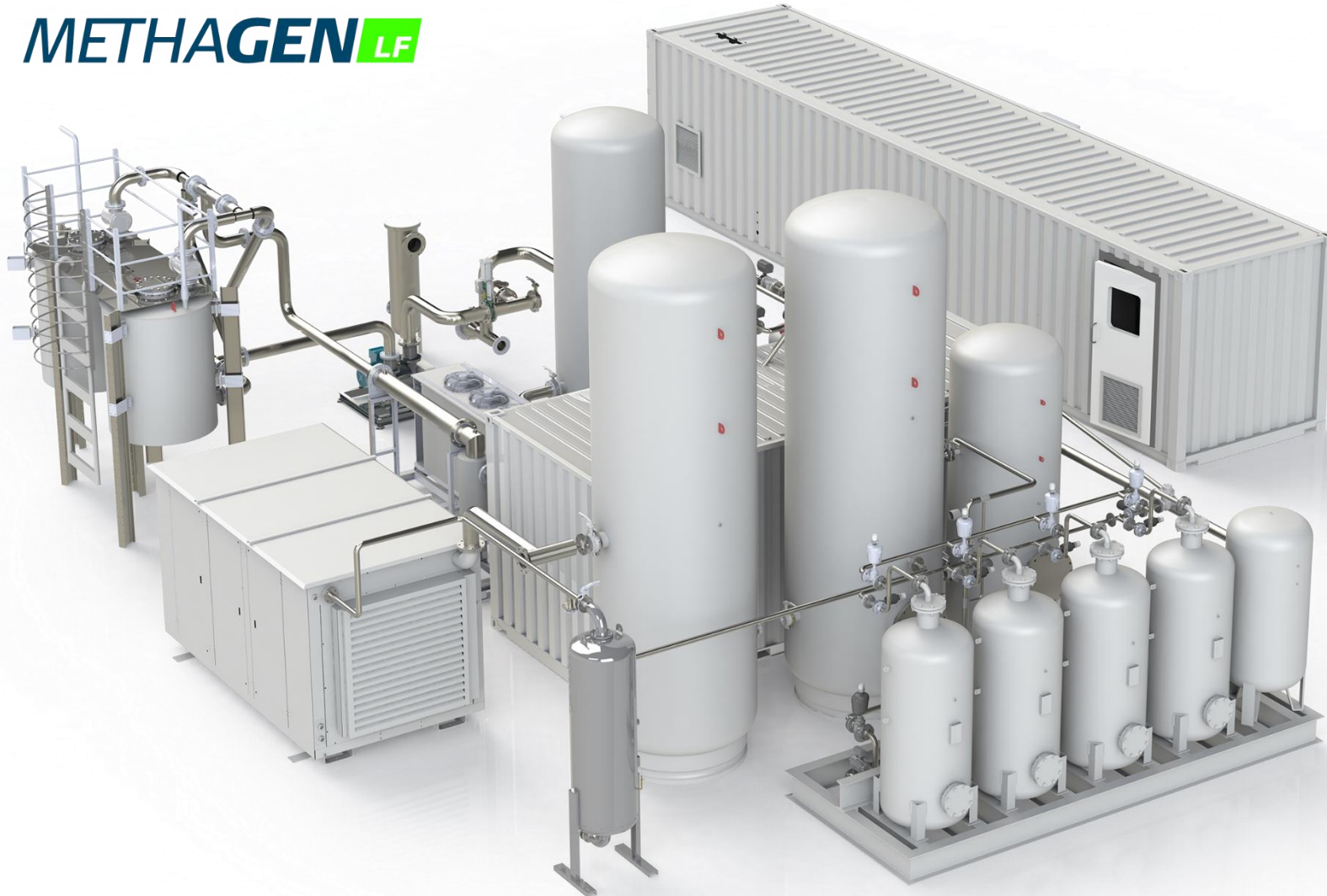
CH₄

METHAGEN **LF** | LANDFILL GAS UPGRADING

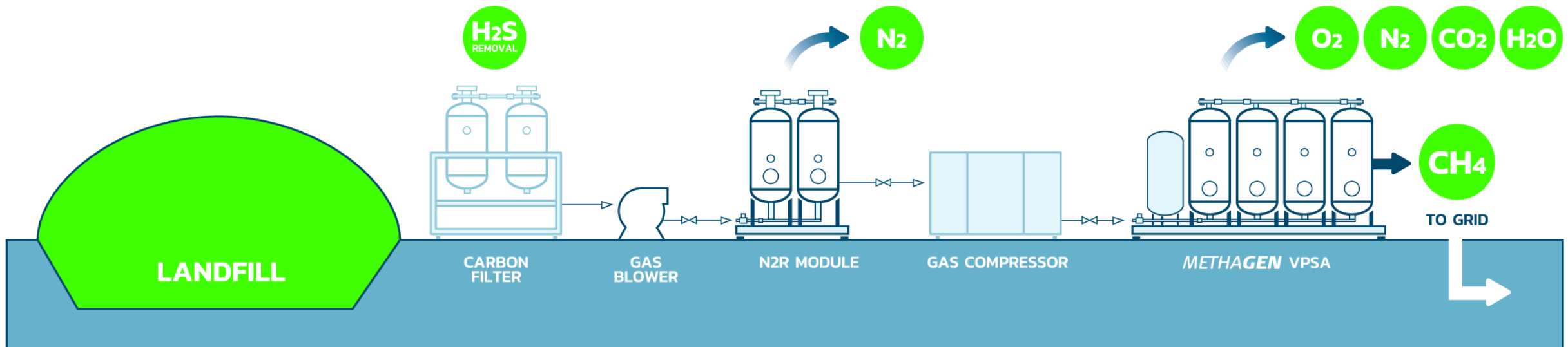
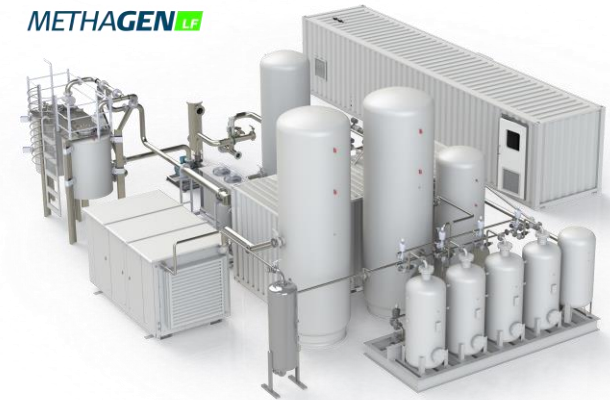
METHAGEN^{LF} | LANDFILL GAS UPGRADING



METHAGEN^{LF}



Pat. pending N2R module
AIR removal up to 19%



METHAGEN^{LF} | LANDFILL GAS UPGRADING



First Landfill injecting in the NG grid w/ non-cryogenic technology

500Nm³/hr - 300 SCFM



Southern Paris, France (2018)



Granada, Spain (2020)



EUROPE

Key Performance Indicators for Double Stage VPSA for Landfill Gas

CH₄ Recovery Rate

> 90 %

Biomethane Purity

up to 98 vol.% CH₄

Biomethane Delivery Pressure

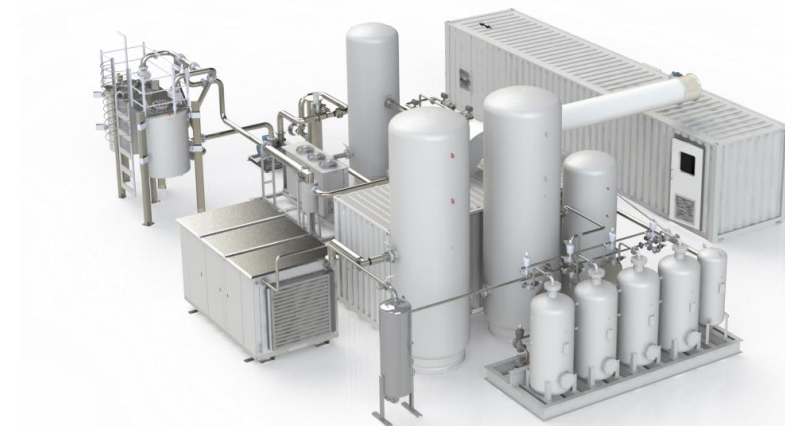
> 5.5 barg

Biomethane Pressure Dew Point

< -50°C

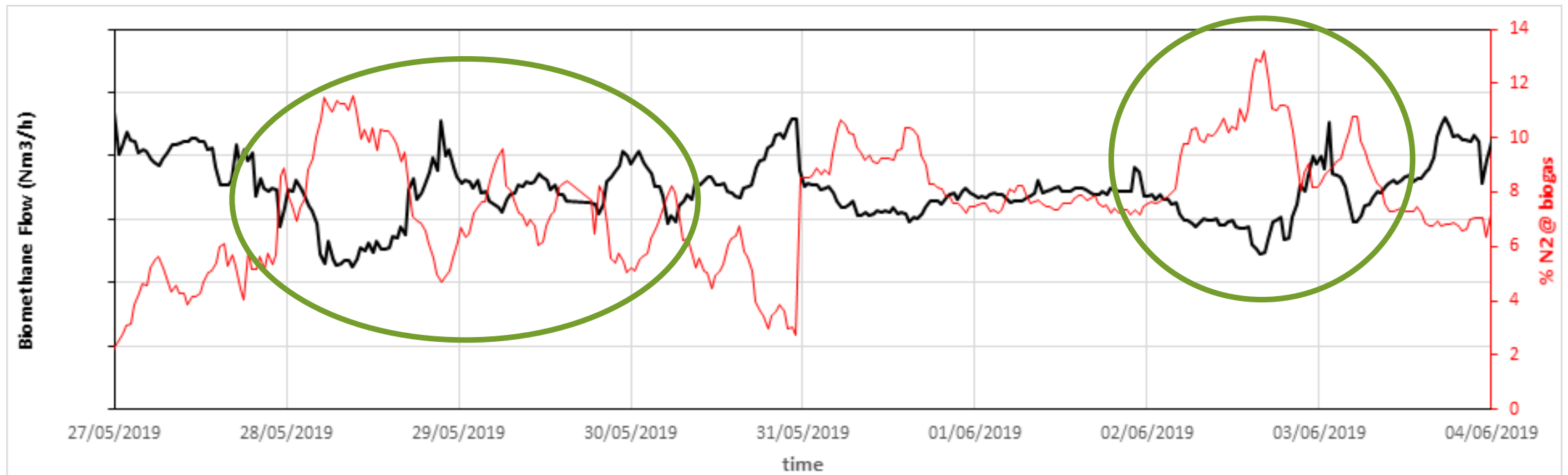
Specific Power Consumption

0,78 kWh/Nm³ / 1.2 kWh/SCF BIOMETHANE*



**Pre-treatment Included*

- AIR removal capacity up to 19 vol.%
- Fast plant operational readiness
- Excellent process response to AIR steep variance





- Lowest OPEX > 0.30 kWh/Nm³ / 0.48 kWh/SCF of biogas
- Efficient O₂ and CO₂ removal
- Dry process - no water or chemicals (dewpoint < 50 ppm_v)
- Non-Cryogenic - no need for liquid N₂

CO₂



CARBOGEN

| CO₂ RECOVERY AND PURIFICATION

sysadvance

CARBOGEN | CO2 CAPTURE AND PURIFICATION



CARBOGEN





CARBOGEN is a cleantech VPSA for capture and purification of CO₂ from:

- biogas upgrading waste gas;
- flue gas streams ;
- rich industrial streams.

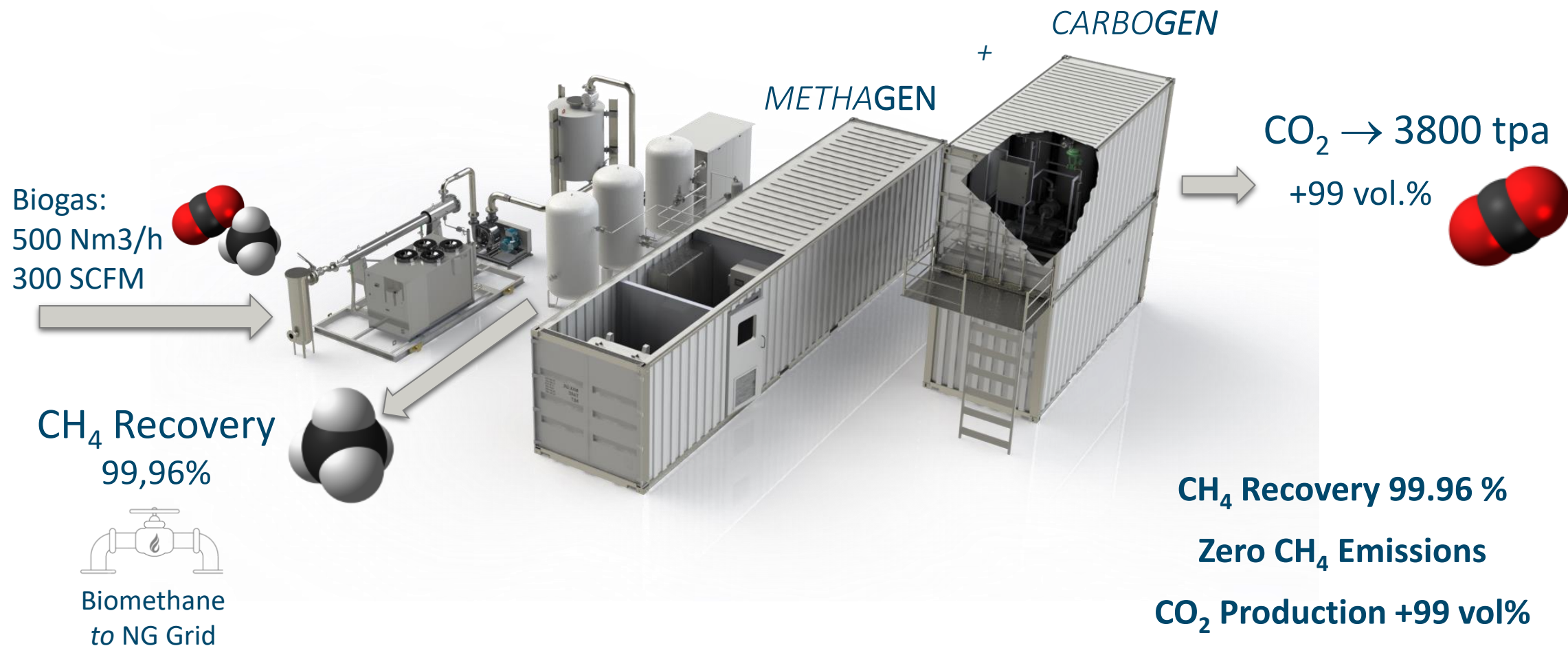
CARBOGEN systems capacities - ranging from 100 Nm³/h to 1000 Nm³/h (60 to 650 SCFM) of CO₂ - rich gas.*

* Other capacities available under request.



- Greenhouse Farming
- Food & Beverage
- Purging of Batch Anaerobic Digester
- Control of pH on WWTP for Paper Industry
- Algae Production
- Carbonate Production
- Concrete Curing
- Steel Manufacturing
- Methanation for PtG (Power To Gas)

Combined CCU and Enhanced CH₄ Recovery



CARBOGEN | CO2 CAPTURE AND PURIFICATION



CO2 Purification for industrial application



In cooperation with:





OPEX for CO₂ Capture from Different Sources

CO ₂ Source	CO ₂ % _{IN}	CO ₂ % _{OUT}	Pot. Application	kWh/ton _{CO₂}
From Flue Gas CARBOGEN	10% <i>Patm, sat</i>	50% <i>20 mbarg, Wet</i>	Carbonates, Concrete Curing Greenhouse, Algae Cultivation...	150
From Landfill Gas w/o Upgrading CARBOGEN	42% <i>Patm, sat</i>	98,0% <i>20 mbarg, Wet</i>	Greenhouse, Algae Cultivation, Fire Extinguisher...	153
After Biogas Upgrading Water Wash + CARBOGEN	84% <i>1,5 barg, sat.</i>	99,8% <i>20 mbarg, wet</i>	Inerting/Purging Batch Digesters	35
After Biogas Upgrading METHAGEN	94,0% <i>20 mbarg, wet</i>	99,9% <i>20 mbarg, wet</i>	Industrial Grade or Food Grade (<i>after liquefaction</i>)	51
After Biogas Upgrading METHAGEN + METHABOOST	99,9% <i>20 mbarg, wet</i>	99,9% <i>20 mbarg, wet</i>	Industrial Grade or Food Grade (<i>after liquefaction</i>)	~0

CONTACT INFO

- ▶ José Vale Machado
- ▶ CEO
- ▶ SYSADVANCE SA
- ▶ +351 939 999 062
- ▶ jmvm@sysadvance.com
- ▶ energy@sysadvance.com

- ▶ RNG WORKS Exhibit Space #511