# RENEWABLE ENERGIES

## BIOMETHANE PRODUCTION CASE STUDIES

Carmen Guinea Valle
**Desarrollo Nuevos Negocios**

# A. BIOGAS: Where does it come from?

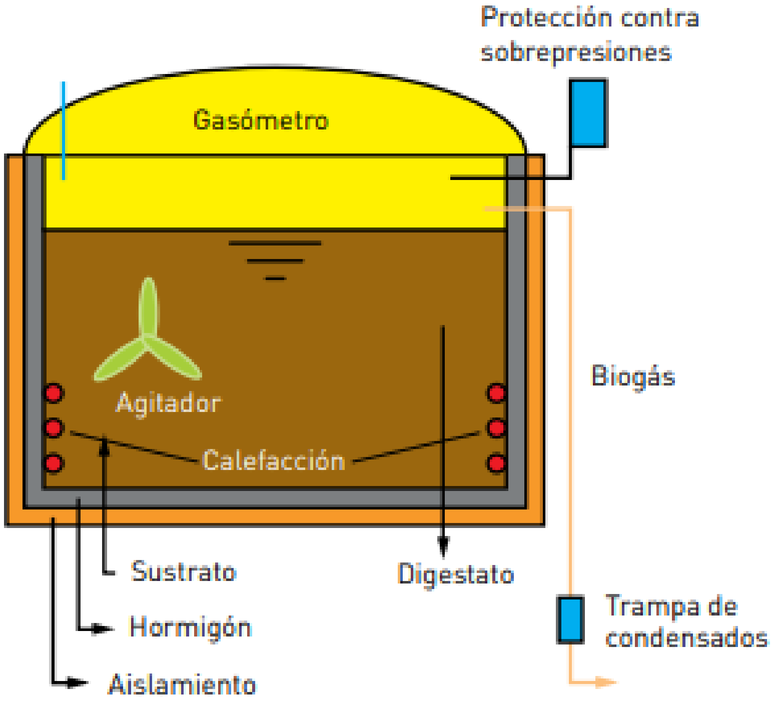
Biogas (BG) is produced in an anaerobic digester (AD) by means of bacteria, in two phases:

1. Digestate (Organic matter) Acidification
2. Transforming the OM in $CH_4$ with bacteria

The AD are hermetic without any emission to the atmosphere:

- $N_2$
- $CH_4$
- Smell
- Flies, etc.

The process lasts 30 days



# B. BIOMETHANE: What is it?

It is a gas with renewable origin, neutral $CO_2$ emissions and totally exchangeable with fossil natural gas (NG).

## Renewable gas characteristics

**Origin** — **Renewable: BIOGAS**

**$CO_2$ Emission** — **Neutral emissions of $CO_2$**

**USES** — **Same as Natural Gas (NG)**

## 3 production options

| | | | Market maturity |
|---|---|---|---|
| A |  | BIOGAS (AD) + UPGRADING | HIGH |
| B |  | BIOMASS GASIFICATION (THERMAL) | MEDIUM |
| C |  | POWER TO METHANE & POWER TO HYDROGEN | LOW |

# C. HOW CAN BIOMETHANE BE PRODUCED?

nedgia
Grupo Naturgy

Anaerobic digestion

Biogas (BG)

- $CH_4$ 50-70 %
- **$CO_2$: 30-50%**
- $H_2S$: up to 2000 ppm
- Siloxanes 0-20 mg/m$^3$
- Others: ammonia, etc.

$CO_2$

**UPGRADING**

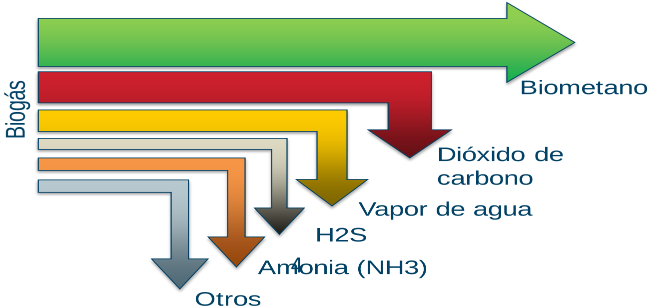
**TECHNOLOGIES**

- ✓ PHYSICAL ABSORPTION
- ✓ CHEMICAL ABSORPTION
- ✓ PRESSURIZED WATER SCRUBBER (PWS)
- ✓ MEMBRANES
- ✓ PRESSURE SWING ADSORPTION (PSA)
- ✓ CRIOGENYC

Biomethane (BM)

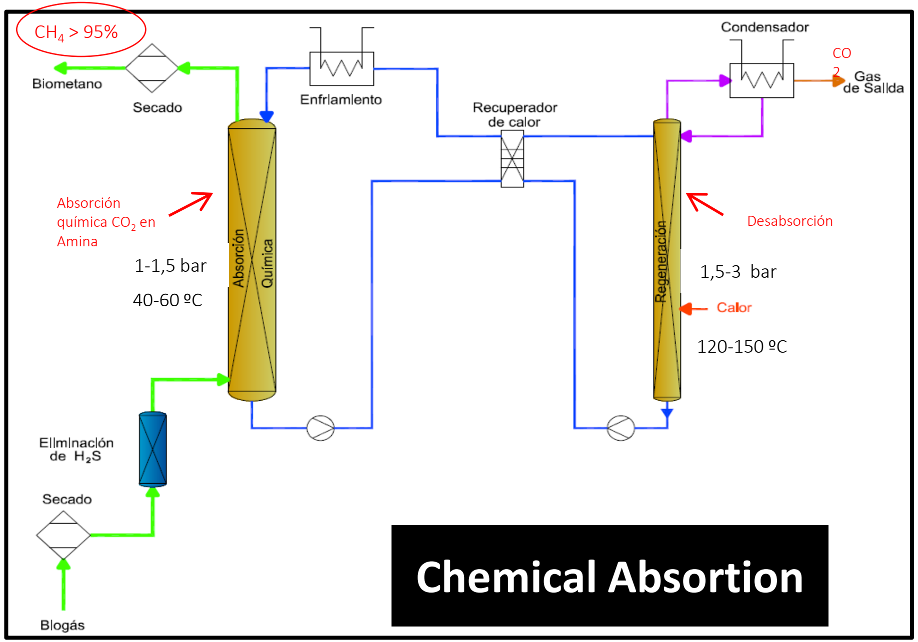
**Injection into the Natural Gas GRID**

- $CH_4 \geq 95\%$
- **$CO_2 \leq 2$ %**
- **$H_2S$ + COS ≤ 15 mg/m3**
- **Siloxanes ≤ 10 mg/m3**
- All other parameters according to regulations




**Upgrading:** Elimination process of $CO_2$ and contaminants ($H_2S$, siloxanes…) present in the biogas

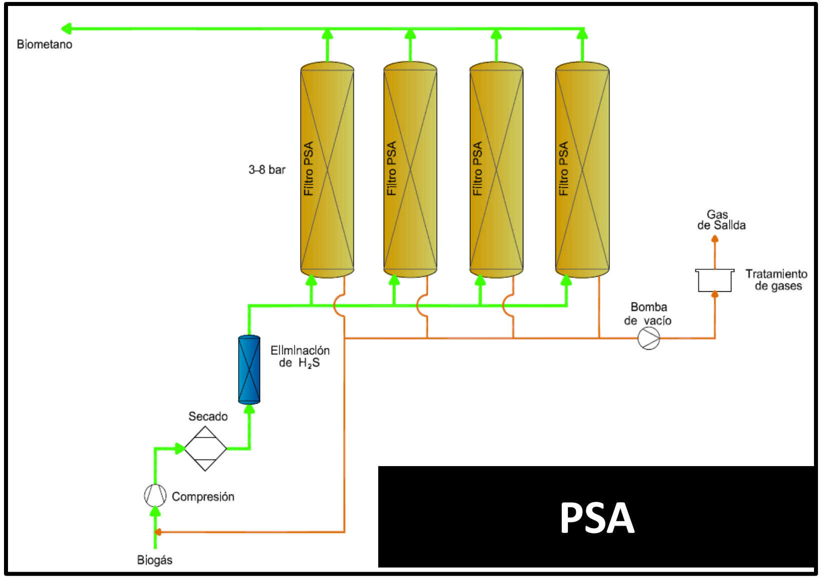
# D. UPGRADING TECHNOLOGIES

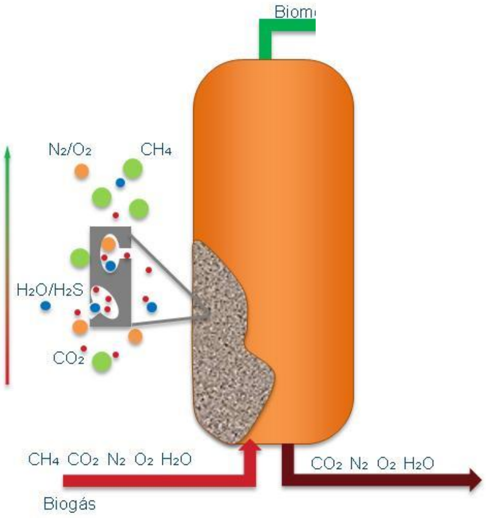



$$\text{Amina .}H_2O + CO_2 \rightleftarrows \text{Amina-}H^+ + HCO_3^- + \text{heat}$$

- Principle of separation: Chemical absorption of CO2 in an amine solution (MEA, MDEA, DEA..)
- $O_2$ and $N_2$ keep going in the BG current
- Higher termal consumption required from the amine regeneration
- Possibility to use the heat excess in other industrial uses

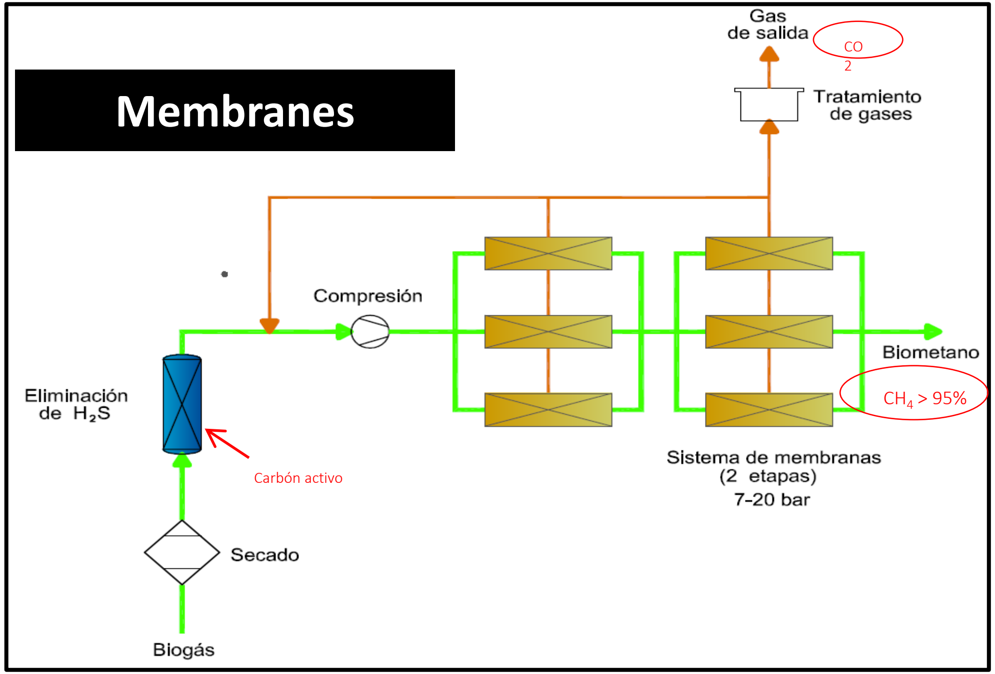
# D. UPGRADING TECHNOLOGIES

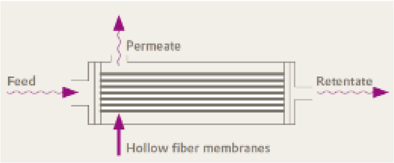


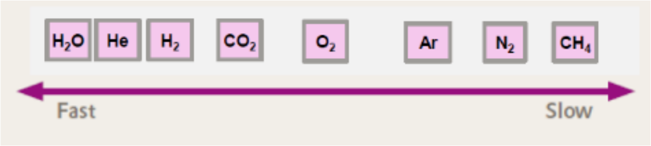




- Principle of separation: flowing presurized Biogas through carbon molecular filters where CO2 is absorbed.
- $O_2$ and $N_2$ are absorbed partially
- Once the carbon molecular is saturated , it is regenarated (depressurized and desorb the CO2) . The process takes around 1-2 min.
- Higher electrical consumption

# D. UPGRADING TECHNOLOGIES



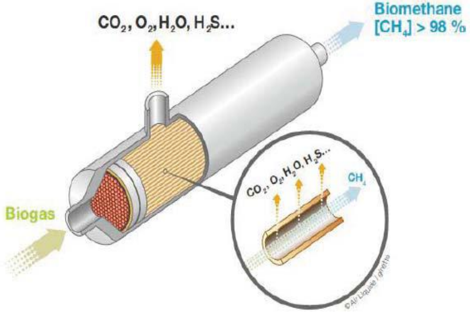

- Principle of separation: Flowing presurized BG through the membranas. These membranes are more permeable to CO2 tan to CH4.
- Severeal stages: 2 or 3
- $N_2$ keeps in the BG current while $O_2$ reduces partially
- Higher electrical consumption

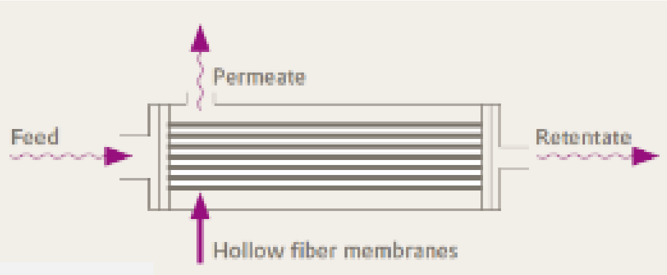
# D. UPGRADING TECHNOLOGIES

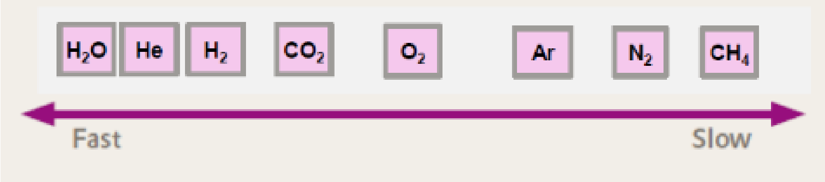
## Membranes

### Mebrane Tecnology  Advantages:

- Modular. Quick installation and commissioning (plug&play)
- Easy operation
- High CH4 recovery
- Flow and CH4 concentration could vary
- High CH4 concentration in BM (>96%)
- Partial reduction of O2
- Smaller installation costs



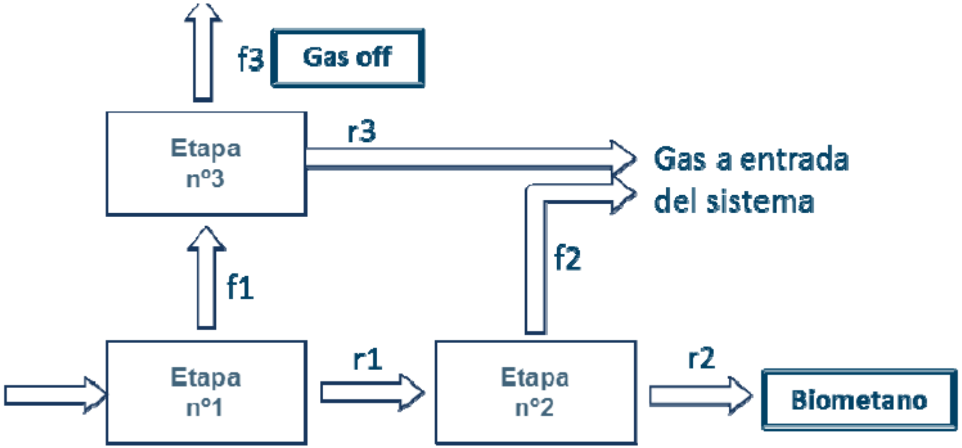



# D. UPGRADING TECHNOLOGIES

nedgia
Grupo Naturgy

## Membranes

Membrane system with 3 stages to get a Higher $CH_4$ recovery >99%, patented by EVONIK.




- With 3 stages $CH_4$ Recovery >99%
- With 2 stages $CH_4$ Recovery around 95%

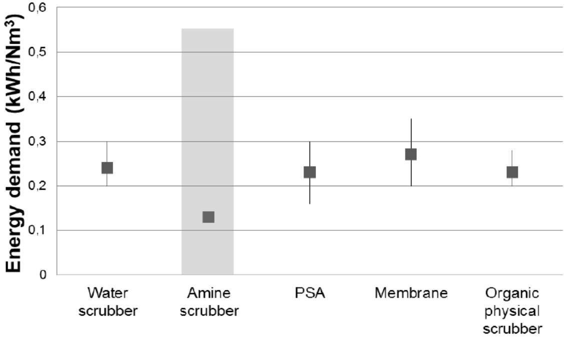
# D. UPGRADING TECHNOLOGIES

## Overall comparison of technologies

| | PSA (adsortion) | Pressurized Water Scrubber (PWS) | Chemical absorption (amines) | Membrane (2-3 stages) |
|---|---|---|---|---|
| Electricity demand ($kWh/Nm^3BG$) | 0,16-0,3 | 0,2-0,3 | 0,06-0,17 | 0,3-0,45 |
| Heat demand($kWh/Nm^3BG$) | No | No | 0,4-0,8 | No |
| Losses of $CH_4$ % | 1-2 | ~1 | ~0,1 | 0,5-1 |
| Operating pressure, bar | 1-10 | 4-10 | 0,05-4 | 7-20 |
| Operation temperature, ºC | - | - | 106-160 | - |
| Separation of $N_2$ and $O_2$ | Partially | No | No | Partially ($O_2$) |
| Requirement of $H_20$ | No | Yes | Yes | No |
| Separation of $H_2S$ | External | Yes | External | External |

**Energy demand**

(Various pressure in the product gas and heat recovery potentials)

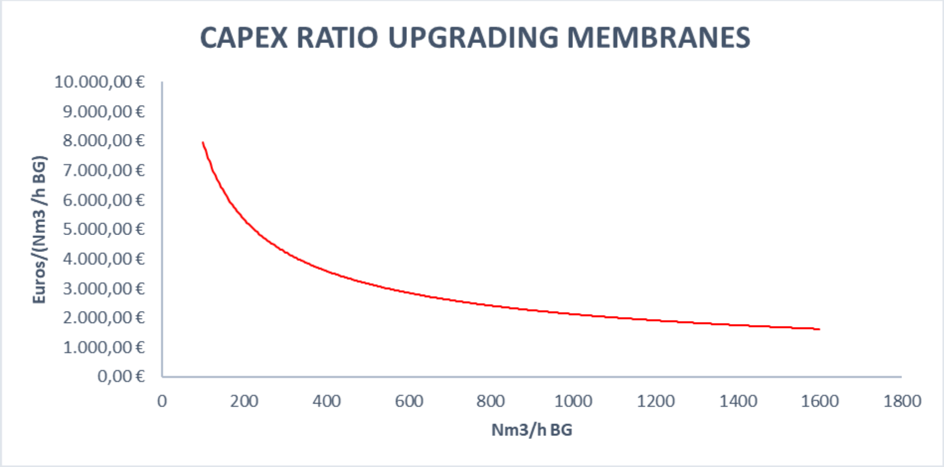


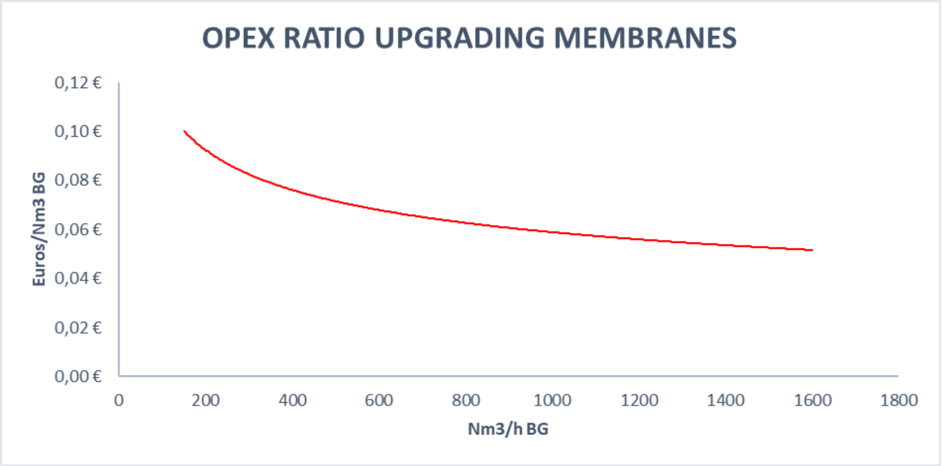

Sources SGC; AIE, Fraunhofer IWES,Otros

The availability of all the technologies is 95%
They reach $CH_4$ concentrations in the outlet gas over 95%

# D. UPGRADING TECHNOLOGIES

## Membranes




- CAPEX
  - ✓ Pretreatment including active carbon filters
  - ✓ Upgrading

- OPEX:
  - ✓ Electrical consumption: 0,3-0,45 KWh/Nm3 BG
  - ✓ Active carbon: 1,5-2 g Active Carbon/Nm3 B considering 300 ppmv H2S
  - ✓ Supervision and operation
  - ✓ Maintenance cost

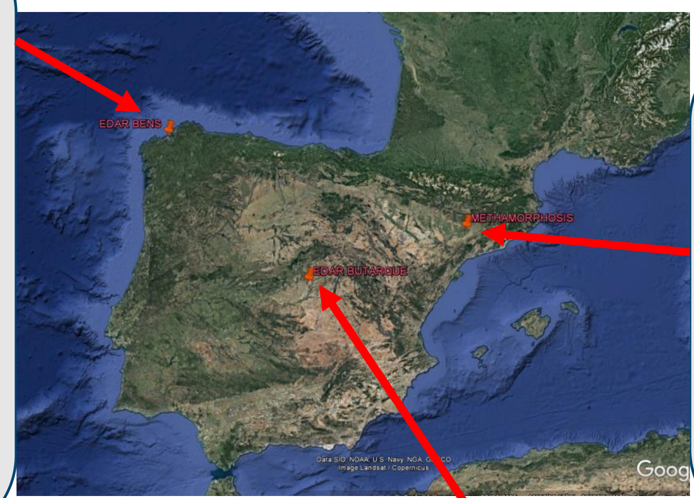
# E. CASES STUDIES


nedgia
Grupo Naturgy

# E. CASES STUDIES

## WWTP BENS

- Upgrading : 100 $m^3/h$ BG from the sludge of a WWTP in Galicia .
- Technology: membranes
- Used in mobility
- Injecting into the grid in Dec 2020.
- CAPEX: 1,1M€
- BM production: 5,5 GWh/year



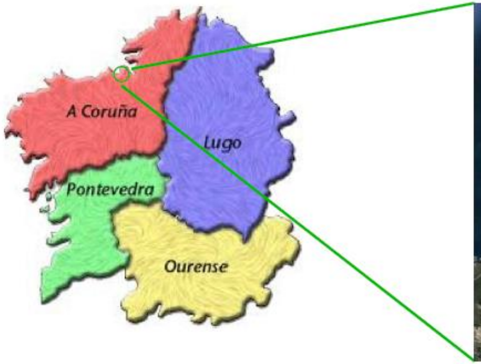

## METHAMORPHOSIS

- Upgrading: 214 $m^3/h$ BG from pigs slurries and other organic rests from Catalunya, located in a farm.
- Technology: membranes
- Future grid injection and present use in mobility
- CAPEX: 1,2 M€
- BM production: 9,4 GWh/year

## WWTP BUTARQUE

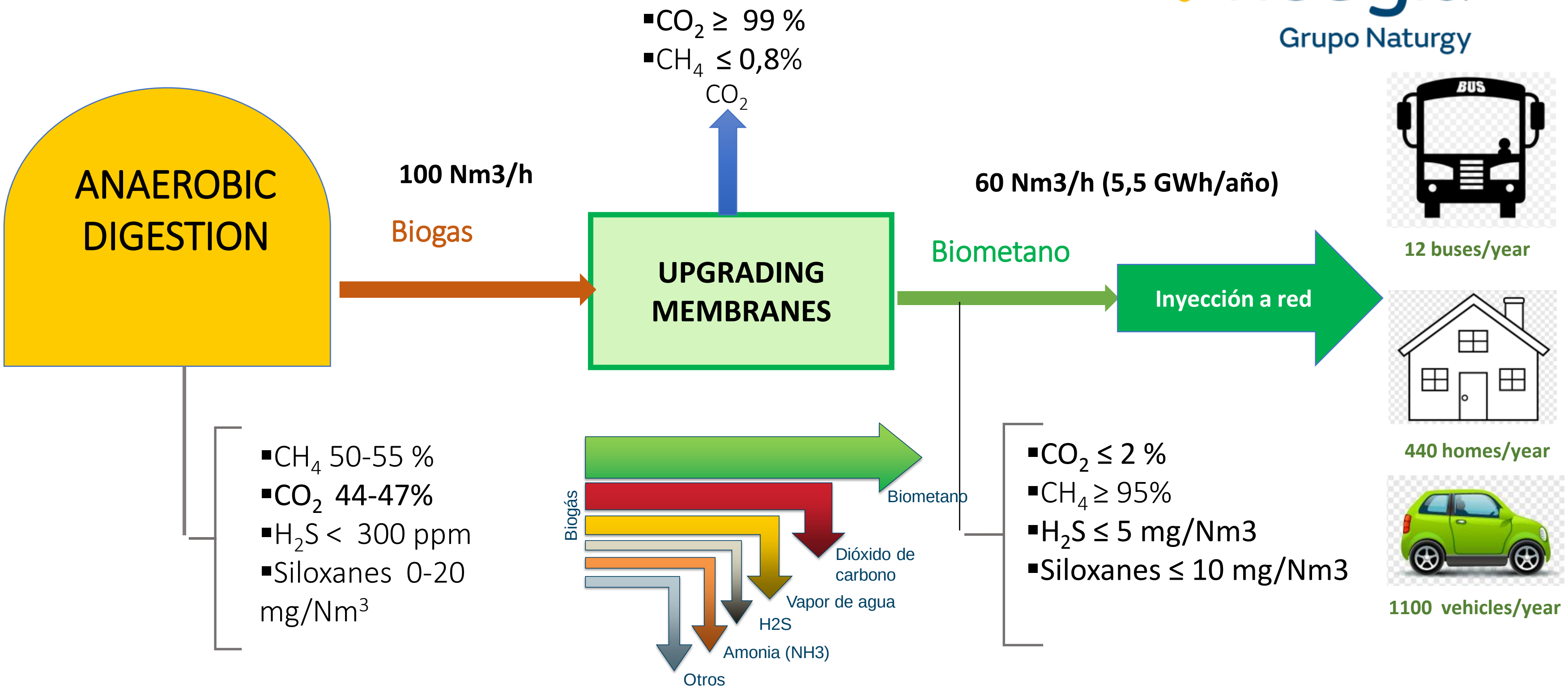
- Upgrading : 100 $m^3/h$ BG from the sludge of a WWTP in Madrid
- Technology: Chemical Adsortion with Amine
- Injecting into the NG grid since October 2019. Also used in mobility.
- CAPEX: 0,8 M€
- BM production: 5 GWh/year

# E. CASES STUDIES: BENS Project

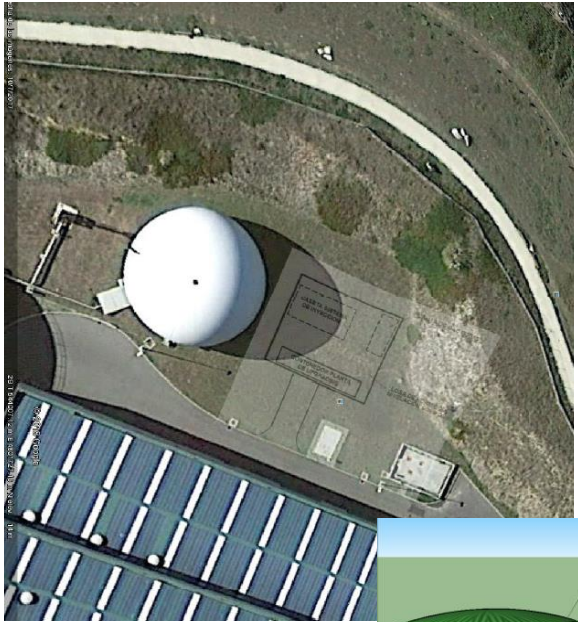


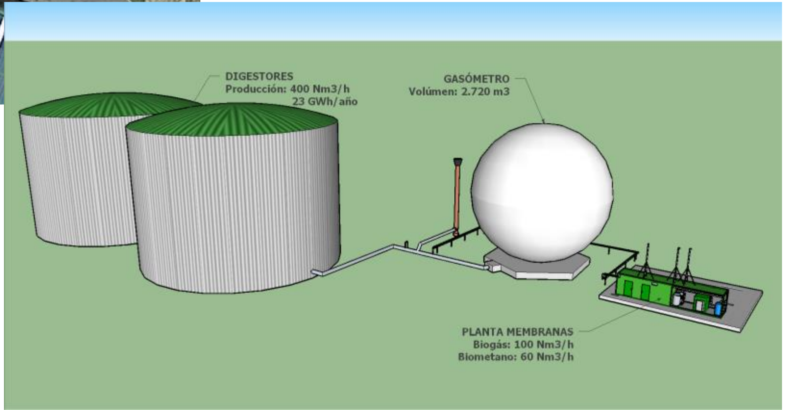


# E. CASES STUDIES: BENS Project



# E. CASES STUDIES: BENS Project






Layout

# E. CASES STUDIES. BENS Project

## Main system parts

UPGRADING

PRETRATAMIENTO

CHILLER AND BLOWER

FILTRATION

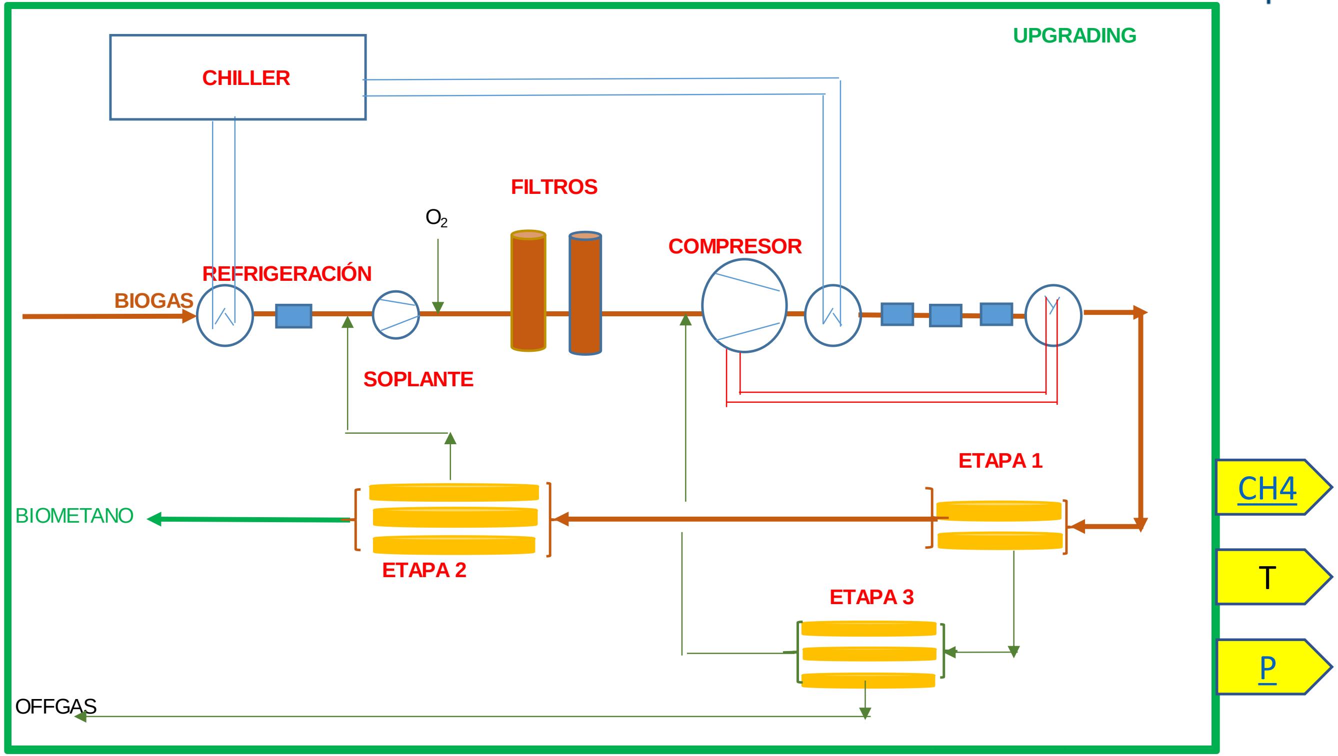
COMPRESSION

MEMBRANES

INJECTION INTO THE NG GRID AND VEHICULAR USE

# E. CASES STUDIES: BENS Project

## Process



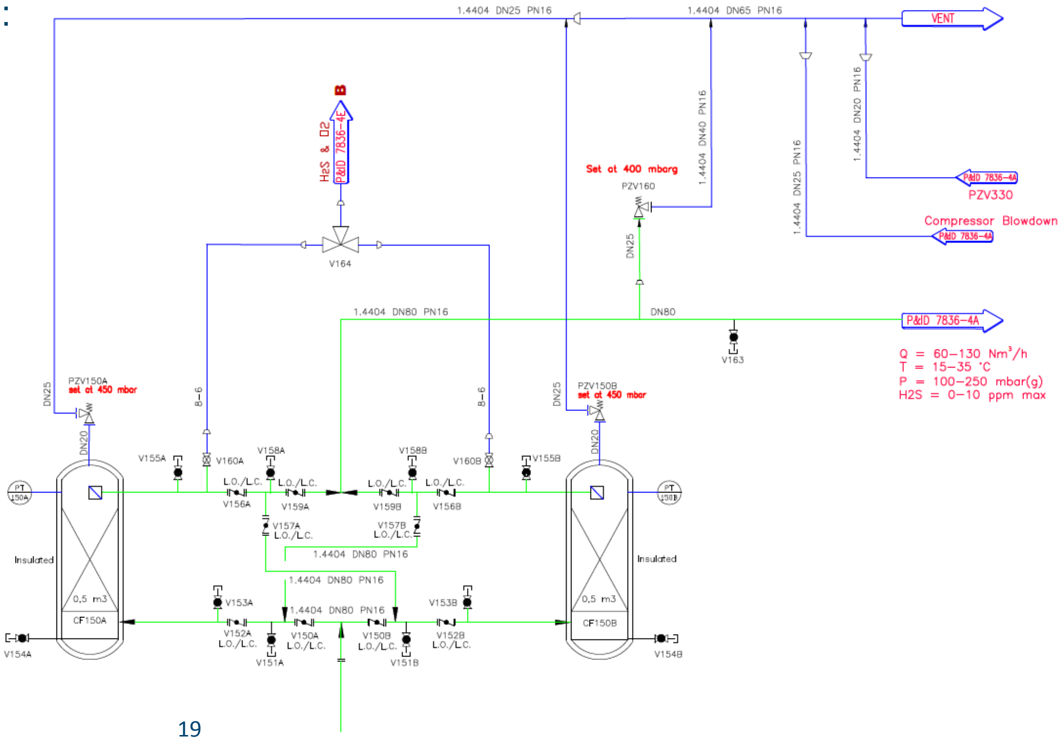
# E. CASES STUDIES. BENS Project

## Activated carbon filters

- 2 Activated carbon filters  to eliminate:
  - VOCs
  - $H_2S$
  - Siloxanes

- Continuous Monitoring  of $O_2$  and $H_2S$ each 30 min

- Safety valve system to avoid over pressures

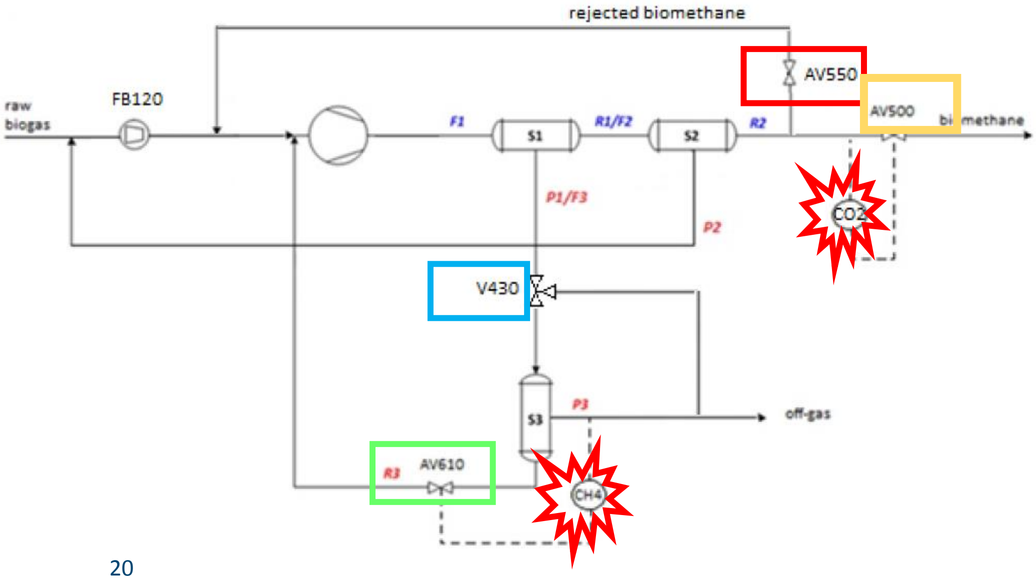


# E. CASES STUDIES: BENS Project

nedgia
Grupo Naturgy

## Process

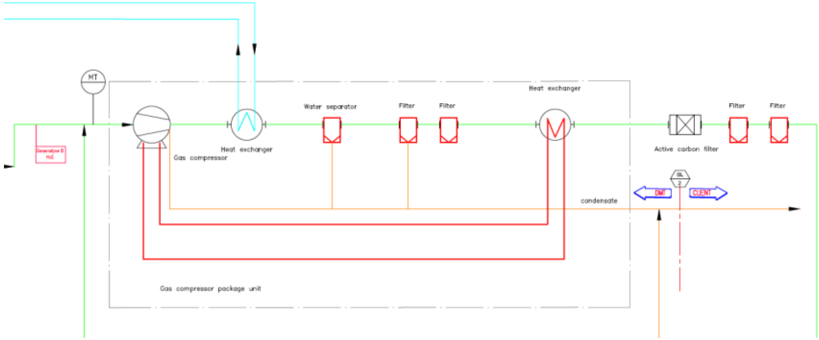
- AV500 regulates pressure in R1, R2 y P2 controling **$CO_2$ in BM**
- If BM quality is incorrect, AV550 recirculates the reject to the compressor and increases the pressure.
- AV550 besides protects of over pressure
- AV610 regulate the pressure in stage 3 controlling the **CH4 in Offgas** (P3) and returning R3 to the compressor.
- P2 is recirculated to the blower
- V430 bypass stage 3



# E. CASES STUDIES: BENS Project

## BG Compressor

- ✓ Inlet controls: P, Tª and water dew point BG + R3
- ✓ Control modes:
  - Maintaining the BG level in the gasometer
  - Maintaining the BG flow at the upgrading inlet
  - Maintaining the BM flow to be produced
  - Maintaining the BM level in the injection system to the NG grid.



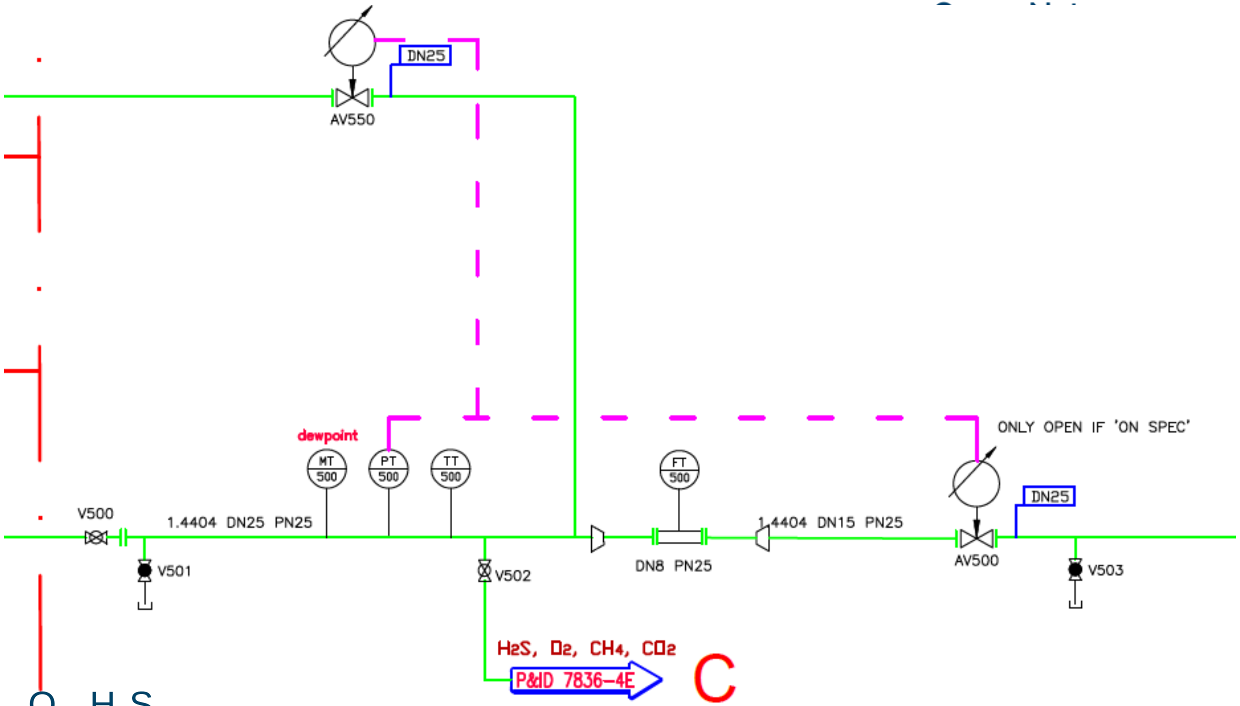

- ✓ Control compressed BG:
  - Cooling system (WDP control)
  - Condensate elimination
  - Temperature Control (reheating)
  - HC and small particle traces filtration

# E. CASES STUDIES: BENS Project

## BM quality and conditions

✓ Monitoring BM produced:

- MT500
- PT500: 10-15 Barg
- FT500
- TT500

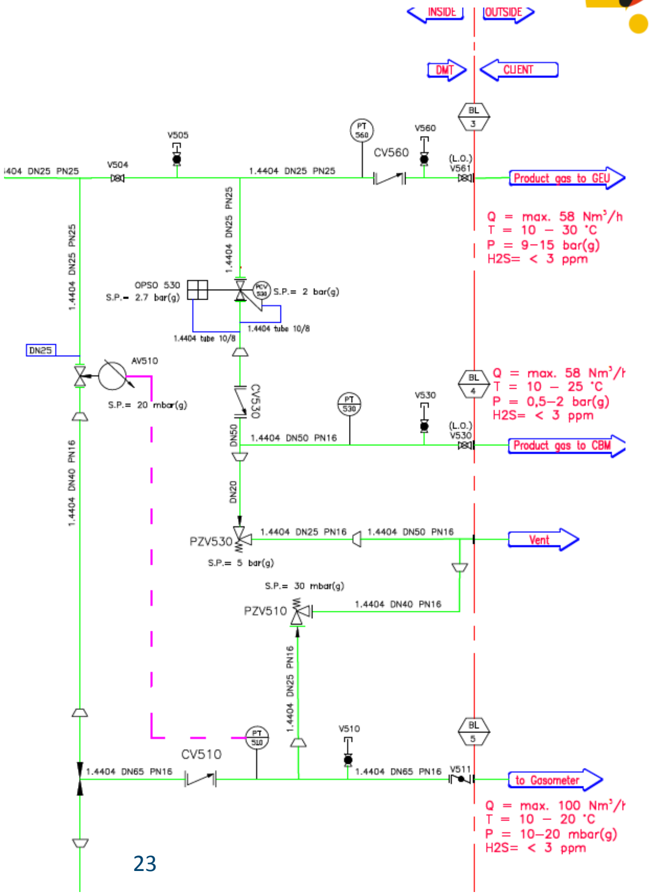



- V502 quality: $CH_4$, $CO_2$, $O_2$, $H_2S$
- Control parameter: $CO_2$

# E. CASES STUDIES. BENS Project

## BM uses

- NG grid injection
- Refuelling station for vehicular use
- Gasometer return



# E. CASES STUDIES. BENS Project

nedgia
Grupo Naturgy

## Monitoring

- **PLC y SCADA system**

- **Biogas and Biometano quality:**
  - Multi-analizer ADOS for Biogas
    - Raw BG: $CH_4$, $CO_2$, $O_2$, $H_2S$ (cada 30´)
    - Pretreated BG:$H_2S$ (each 30´)
    - Offgas:$CH_4$
  - Multi-analizer UNION for Biomethane
    - BM: $CH_4$, $CO_2$, $O_2$, $H_2S$
  - Water dew Point
    - Pretreated BG
    - BM

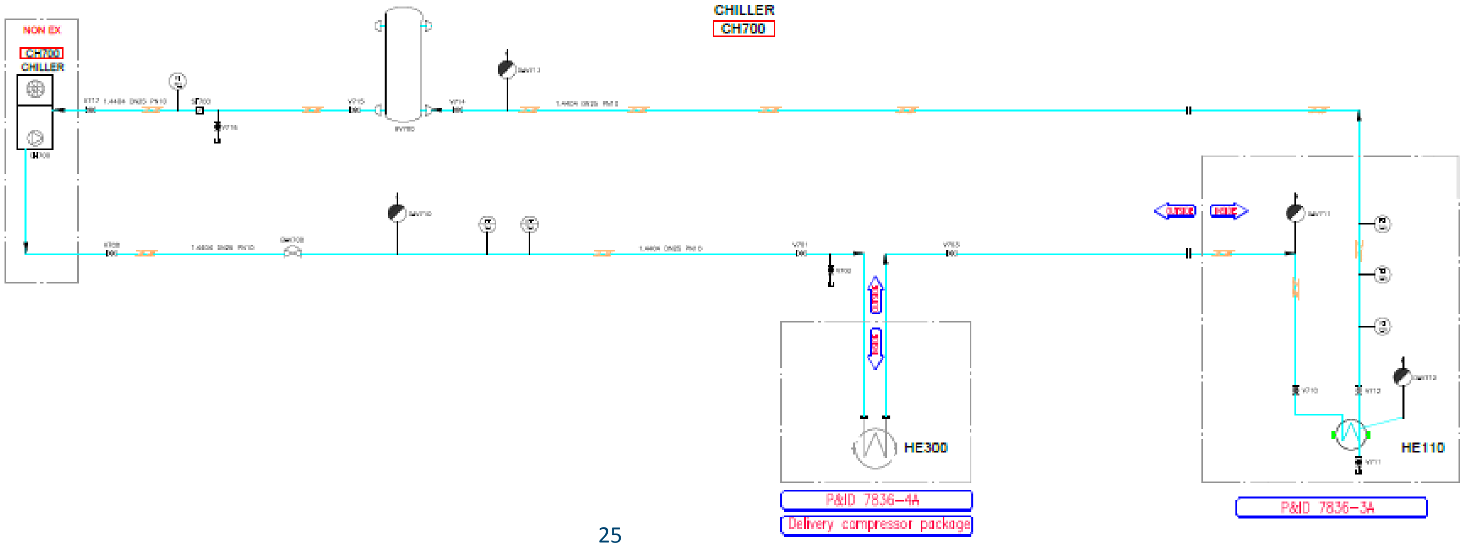
| | | |
|---|---|---|
| Flow clean gas | Mass flow | |
| Flow off gas | Mass flow | |
| Methane content clean gas | IR | 0-100% |
| Methane content off gas | IR | 0-5% |
| Methane raw biogas | IR | 0-100% |
| Carbon dioxide clean gas | IR | 0-5% |
| Carbon dioxide raw biogas | IR | 0-100% |
| Oxygen content clean gas | Chemical | 0-10% |
| Oxygen content raw biogas | Chemical | 0-10% |
| $H_2S$ content raw biogas | Chemical | 0-1000 ppm |
| $H_2S$ content biogas after desulphurisation | Chemical | 0-50 ppm |
| $H_2S$ content clean gas | Chemical | 0-50 ppm |
| Dew point clean gas | | -50 to -10°C |
| Dew point pre-treated gas | | -50 to -10°C |

# E. CASES STUDIES: BENS Project

## Auxiliary sistems: Chiller

<u>Included equipment:</u>

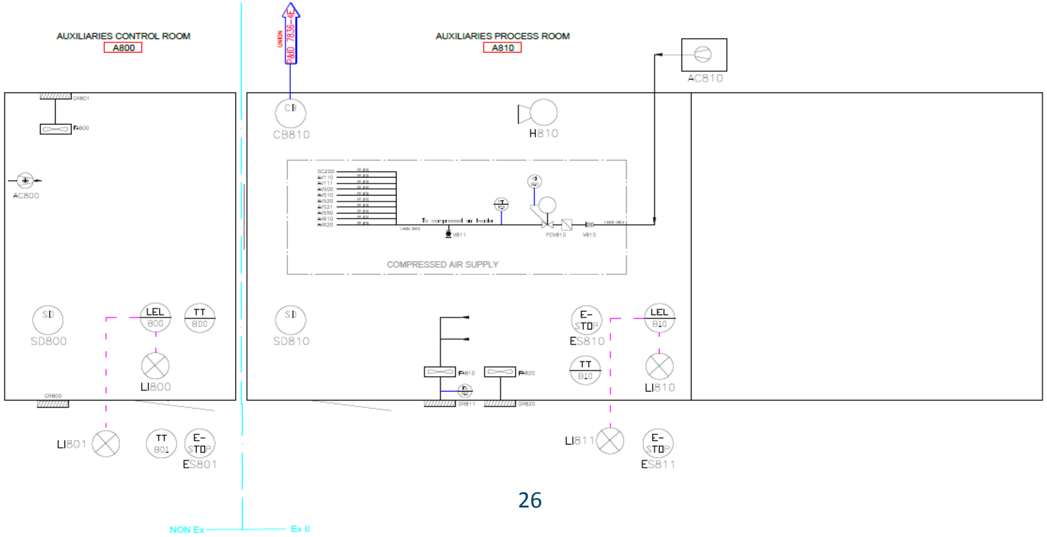
- Chiller
- buffer  tank (3 barg)
- Ciculation pump
- Heat exchangers (from the compressor and the BG)



# E. CASES STUDIES. BENS Project

**Auxiliary systems:**

- Instrument air system
- Air conditioning for the control room
- Safety devices:
  - Detectors LEL and smoke in control room and in process room
  - Ventilation in both rooms (2 ATEX)
  - Acustic and visual alarms



# E. CASES STUDIES. BENS Project

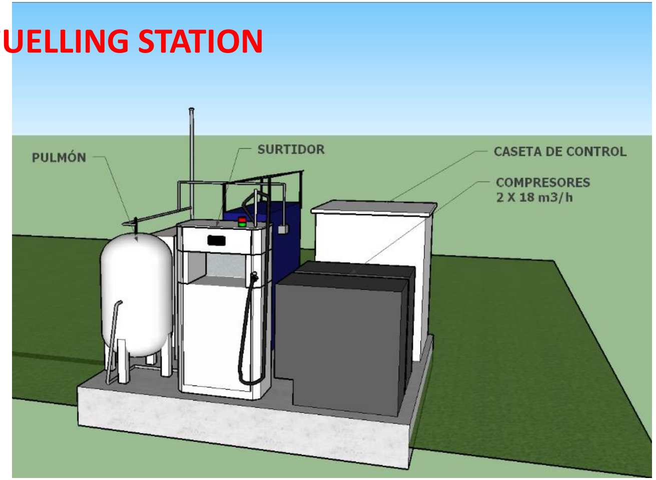
## Installed Power and electrical consumption

- Main consumers
  - BG Compressor: 40 kW (PI)
  - Chiller: 4,2 kW (PI)
  - Blower: 3,2 kW (PI)
  - Instrument air compressor: 2,5 kW (PI)
  - Air conditioning: 1 kW (PI)

| | | |
|---|---|---|
| Installed power | 59 | kW |
| Power consumed | 26.4 | kW |
| Maximum Power consumed at nominal biogas condition | 31 * | kW |
| Maximum Power consumed at nominal biogas condition | 0.33 * | $kWh/Nm^3$ |

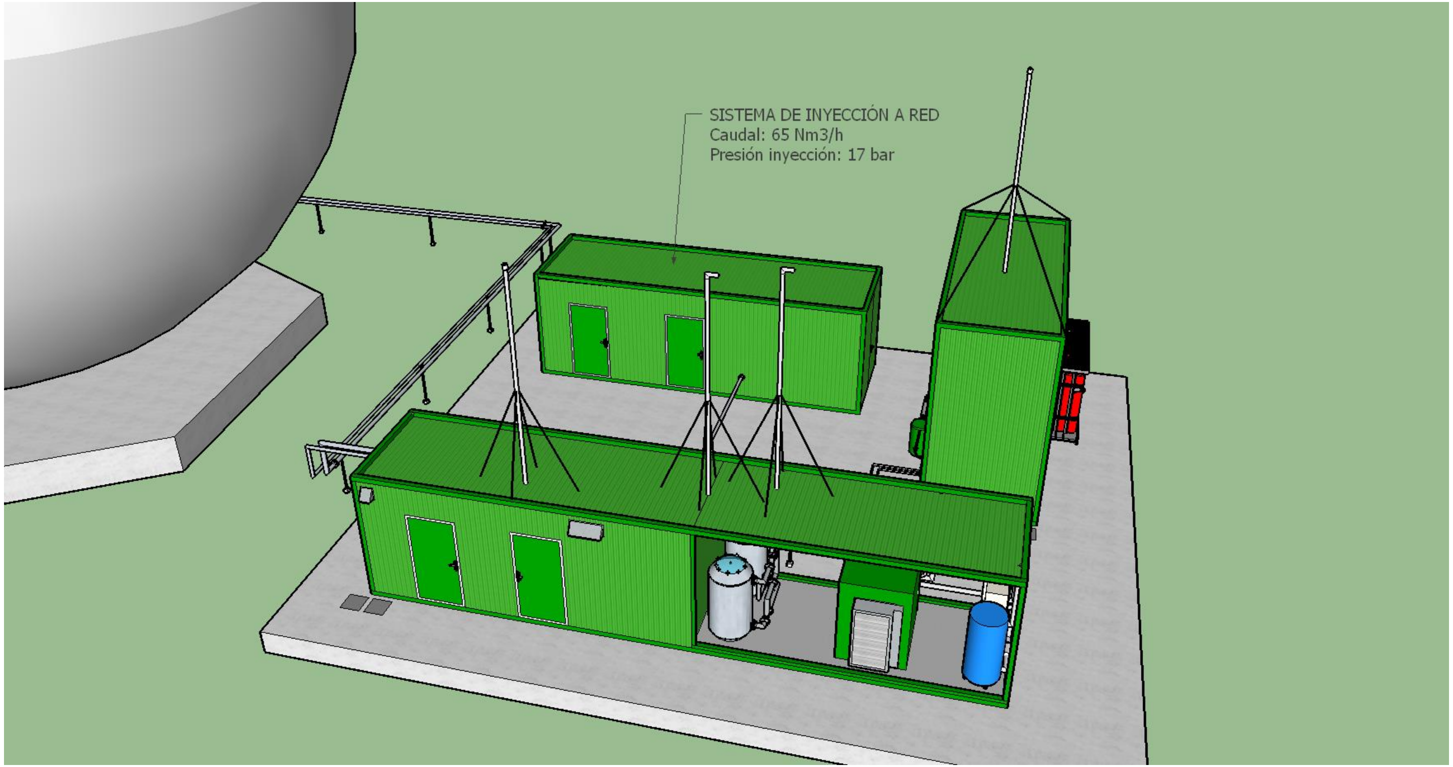
# E. CASES STUDIES. BENS Project

## REFUELLING STATION



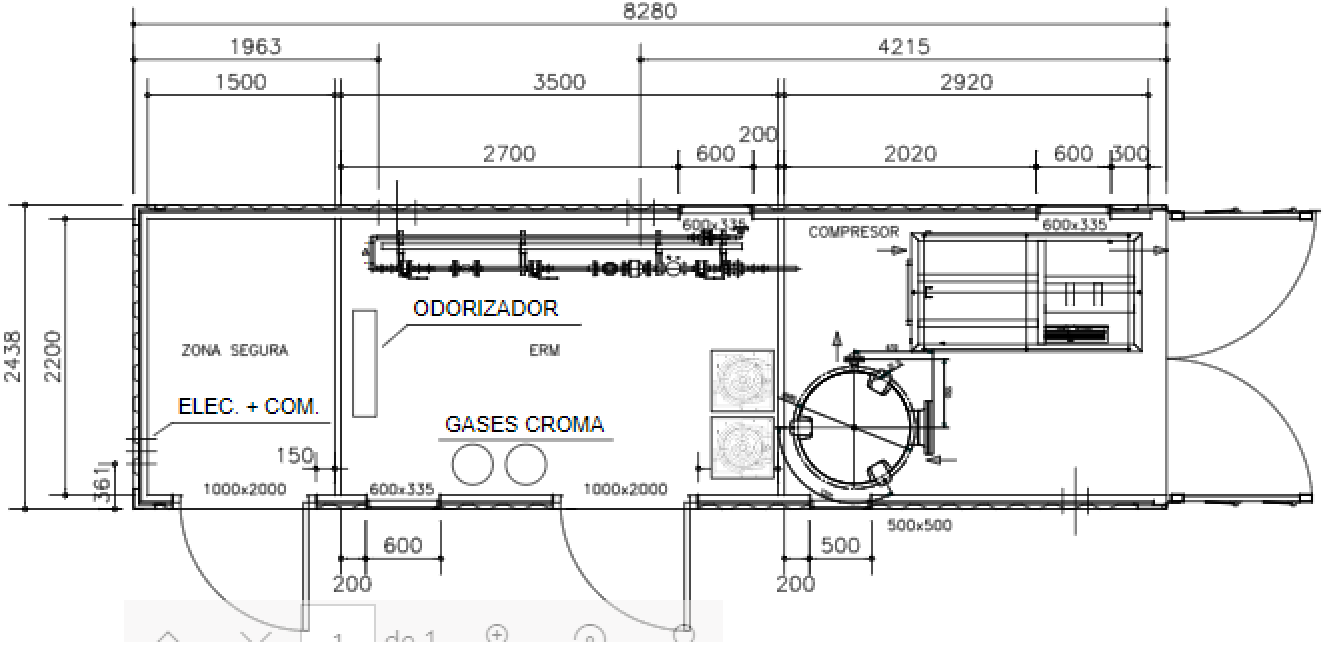


# E. CASES STUDIES: BENS Project



# E. CASES STUDIES: BENS Project

## GAS ENTRY UNIT : INJECTION SYSTEM INTO THE NG GRID

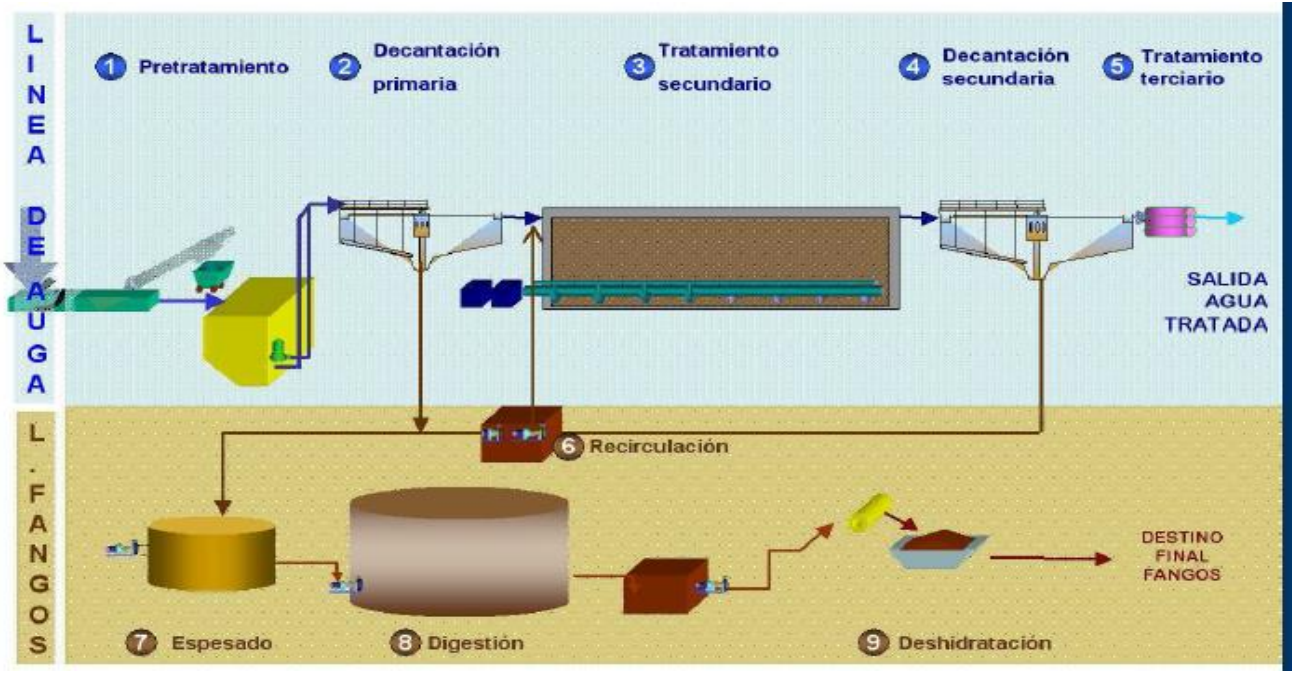


# E. CASES STUDIES: BUTARQUE PROJECT

- Biomethane injected into natural gas distribution network
- Development of the Guarantees of Origin for renewable gas in Spain
- Demonstration of the eco-efficiency of renewable gas for mobility


# E. CASES STUDIES: BUTARQUE PROJECT

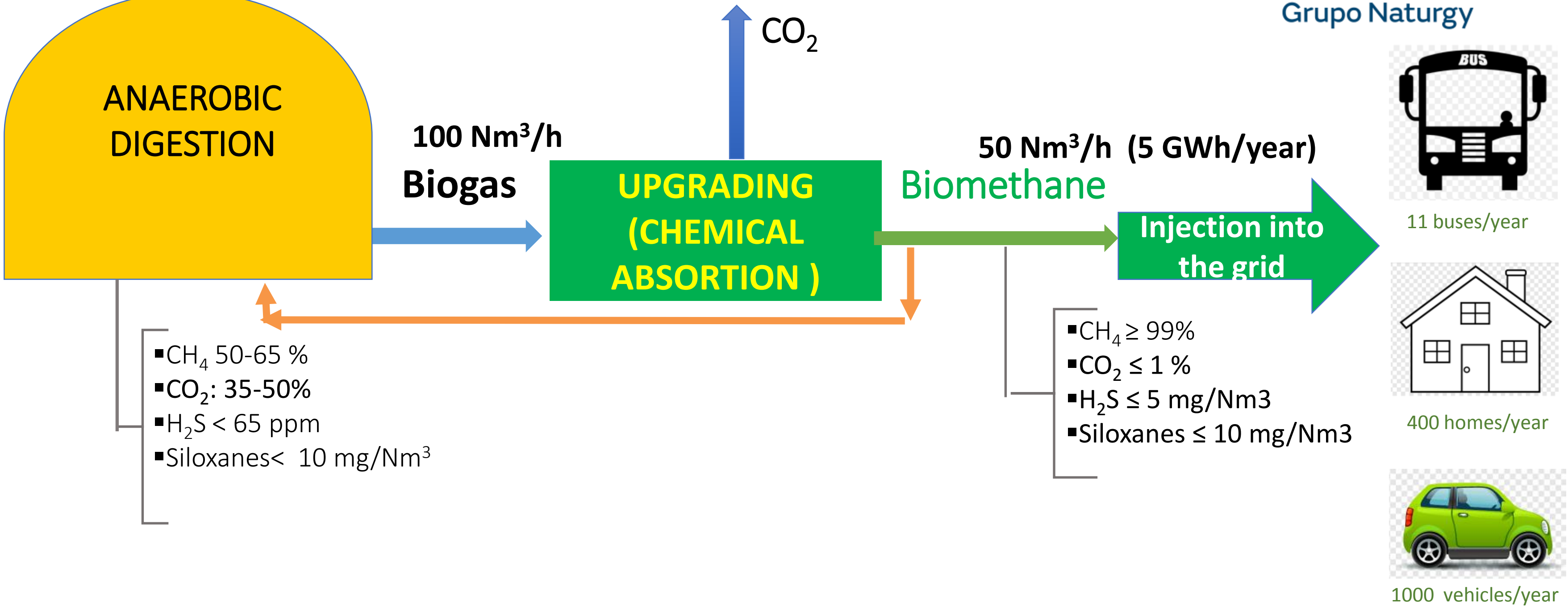
## Wastewater Purification Station (WPS) scheme



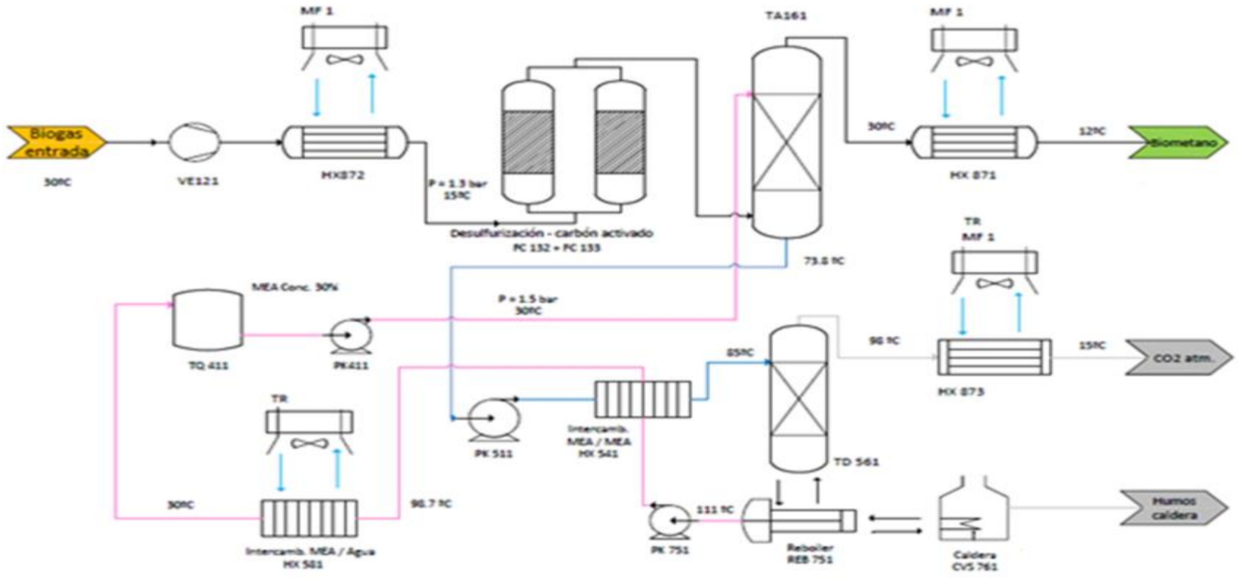

## WPS of Butarque

- Treatment capacity ≈ 1.700.000 population
- The 5th largest in Spain

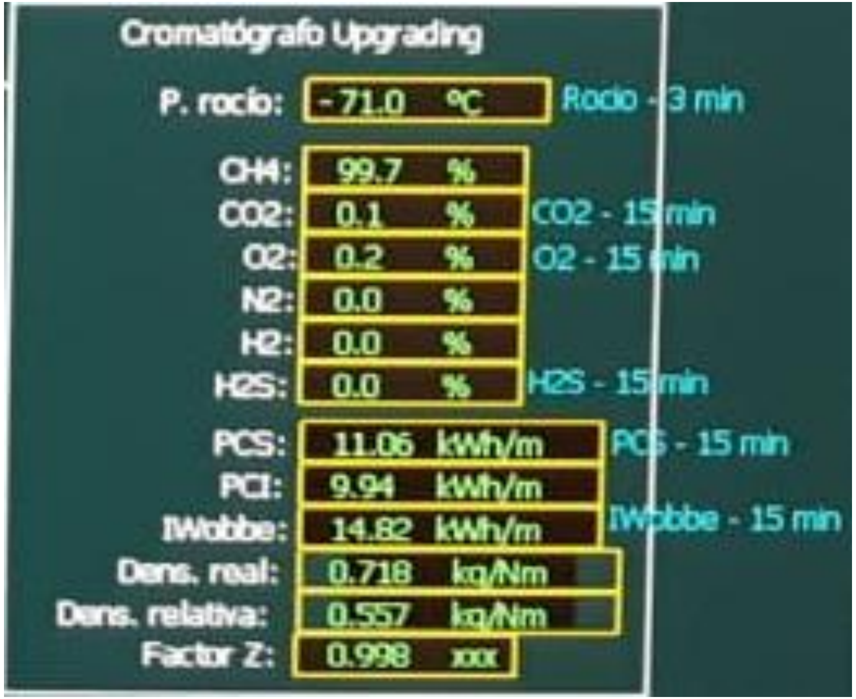
# E. CASES STUDIES: BUTARQUE PROJECT



# E. CASES STUDIES: BUTARQUE PROJECT

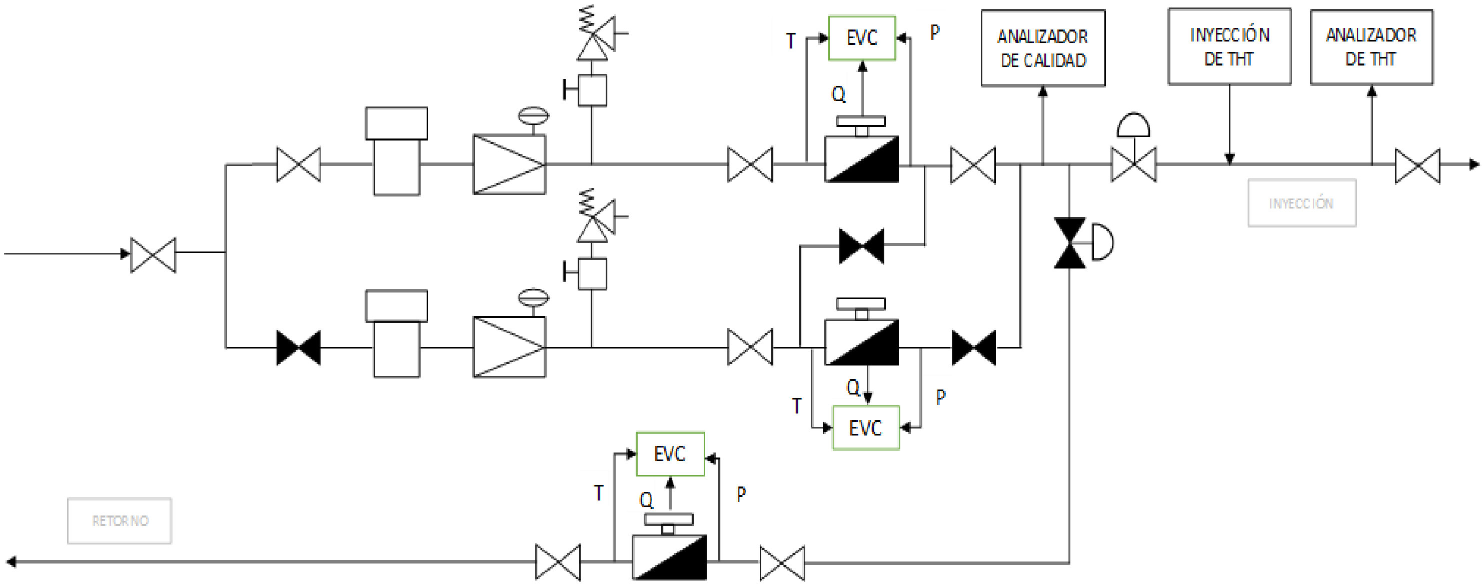


# E. CASES STUDIES: BUTARQUE PROJECT



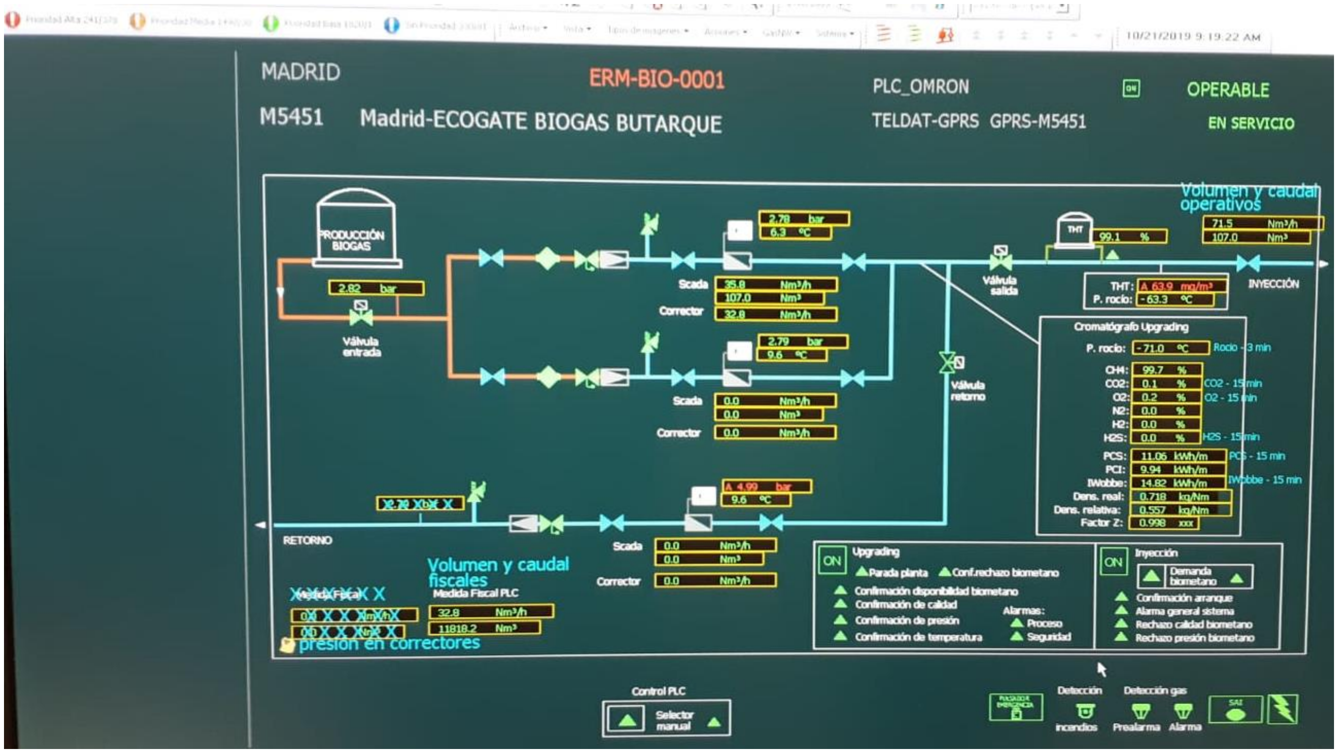
# E. CASES STUDIES: BUTARQUE PROJECT

# E. CASES STUDIES: BUTARQUE PROJECT

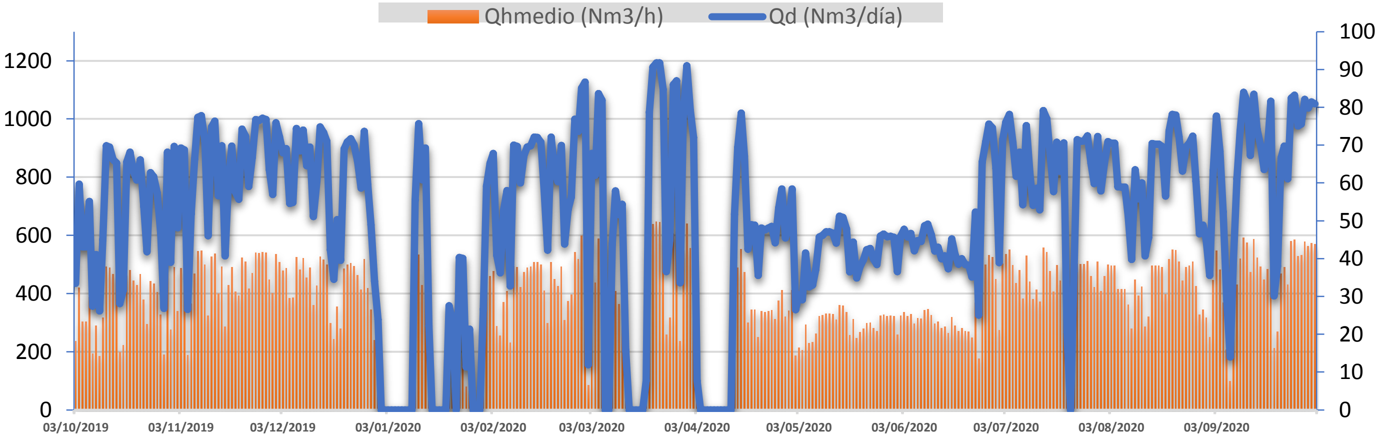


# E. CASES STUDIES: BUTARQUE PROJECT

# E. CASES STUDIES: BUTARQUE PROJECT



# E. CASES STUDIES: BUTARQUE PROJECT




BM INJECTED INTO THE GRID

| | | 05/10/2020 |
|---|---|---|
| **Valores GR inyectado** | | |
| **Total GWh** | **2,553** | |
| **Nm3/día** | **Nm3/hora** | **MWh/día** |
| **666** | **28** | **7,0** |

**El GR inyectado hasta ahora equivaldría al consumo anual de:**

| | |
|---|---|
| 511 | viviendas |
| 204 | vehículos utilitarios |
| 51 | taxis |
| 9,1 | camiones RSU |
| 5,7 | autobuses urbanos |

# E. CASES STUDIES. Methamorphosis Project

- Catalunya, Spain. Porcaporcs farm. Vila Sana. Lleida
- Biogas (BG) anerobic co-digestión 45T/day of waste products (45% pig slurries + 50% waste from WWTP+ 5% wastes from food industry)
- Farm BG production: 200 Nm$^3$/h


# E. CASES STUDIES. Methamorphosis Project

Grupo Naturgy

ANAEROBIC DIGESTION

170-214 Nm3/h

**Biogas**

- $CH_4$ 50-70 %
- **$CO_2$: 30-50%**
- $H_2S$ < 210 ppm
- Siloxanes< 0-40 mg/Nm$^3$

$CO_2$

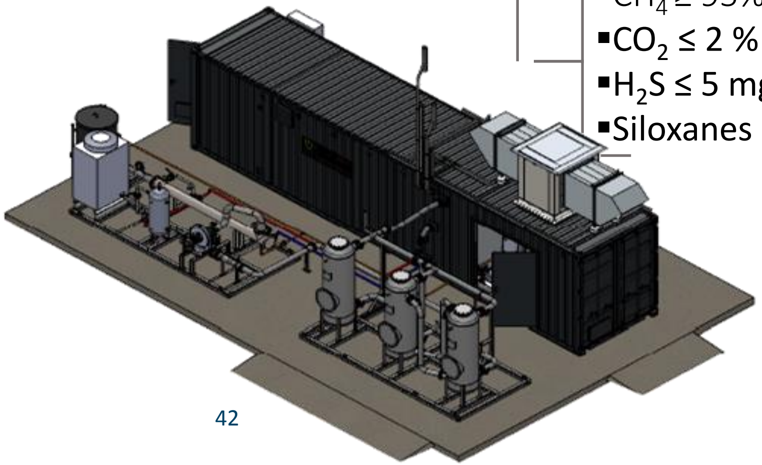
**UPGRADING (Membranes)**

**100- 135 Nm3/h (9,4 GWh/year)**

Biomethane

**Refuelling station**

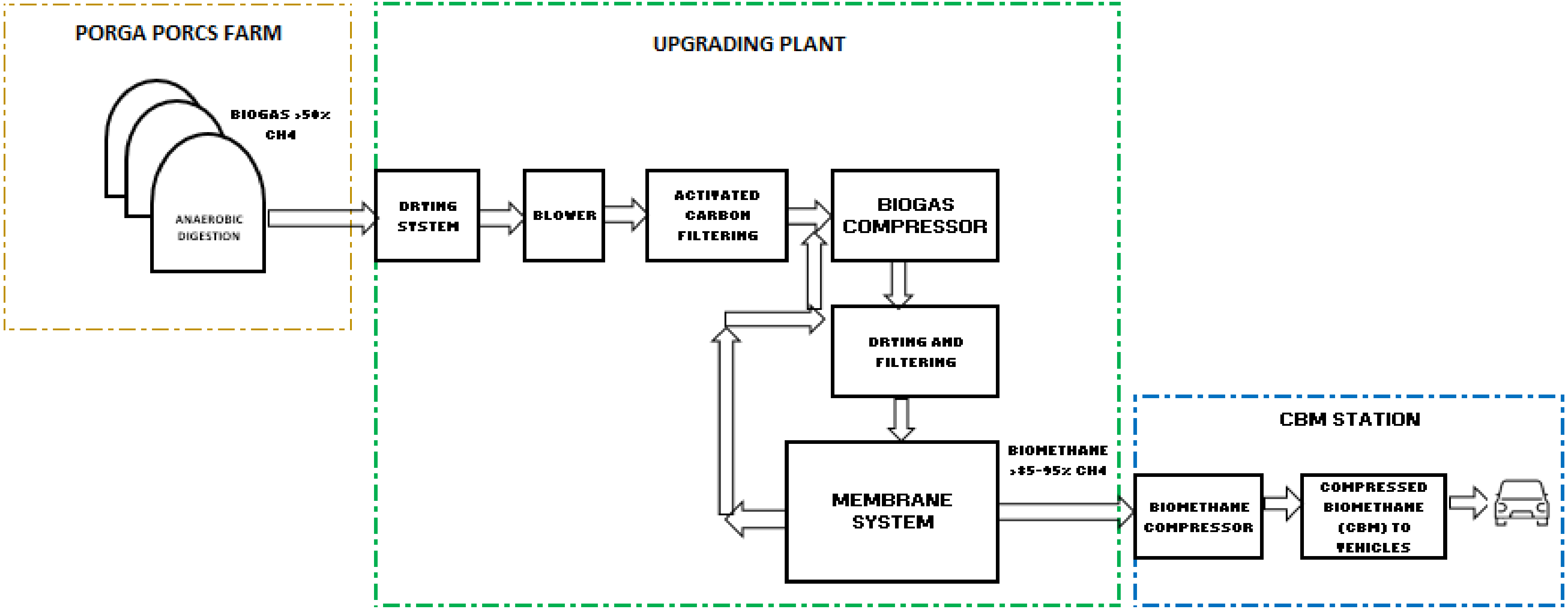
- $CH_4 \geq 95\%$
- $CO_2 \leq 2\ \%$
- $H_2S \leq 5$ mg/Nm3
- Siloxanes ≤ 10 mg/Nm3




**21 buses/year**

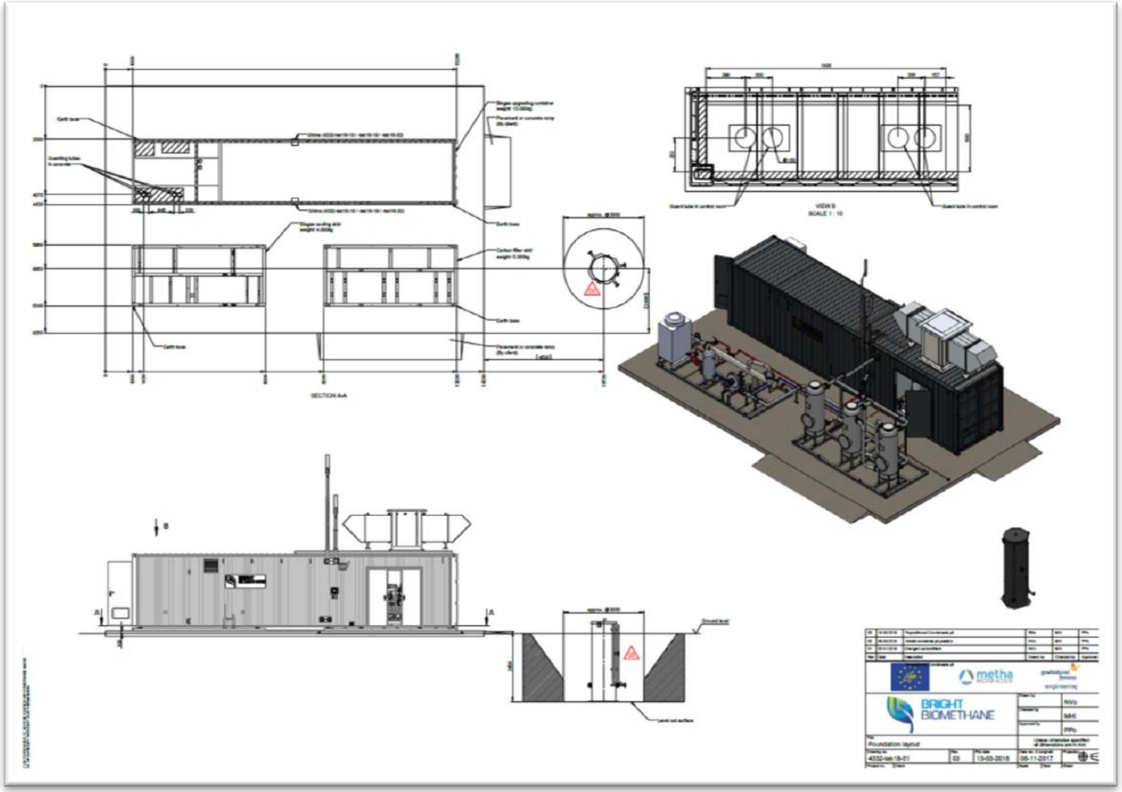
**752 vehicles/year**

# E. CASES STUDIES. Methamorphosis Project



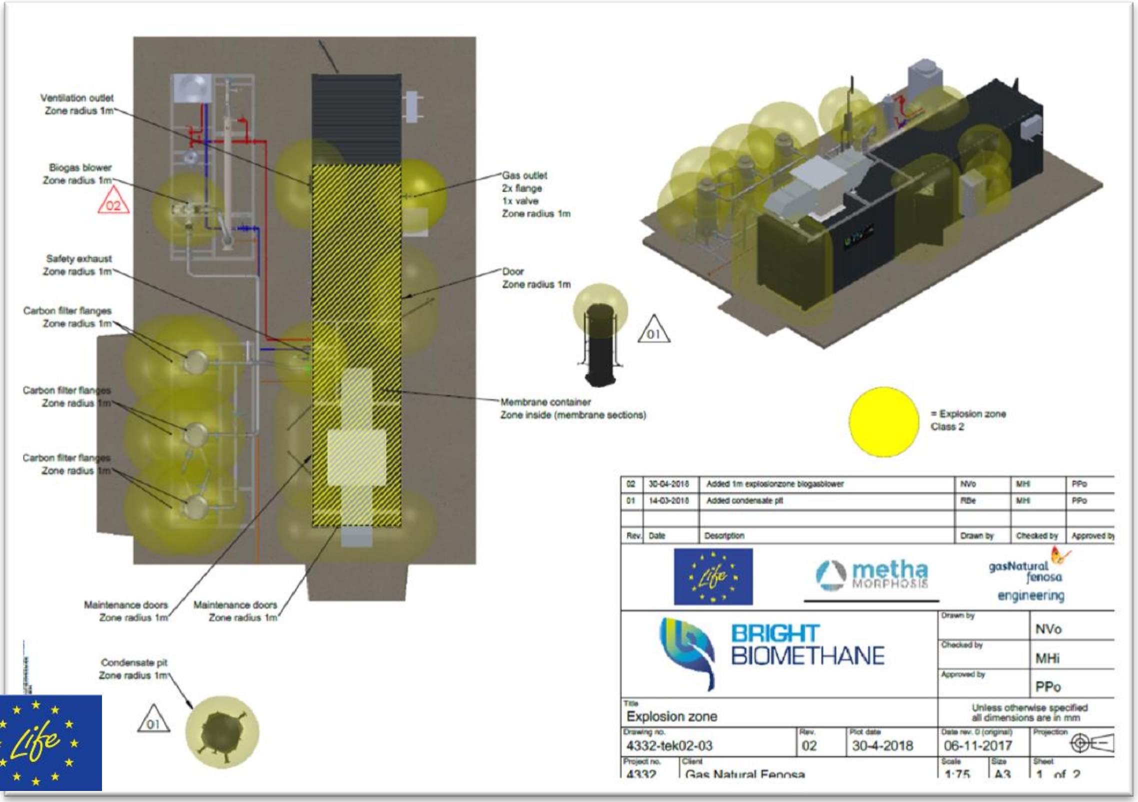
# E. CASES STUDIES. Methamorphosis Project

## DETAIL ENGINEERING



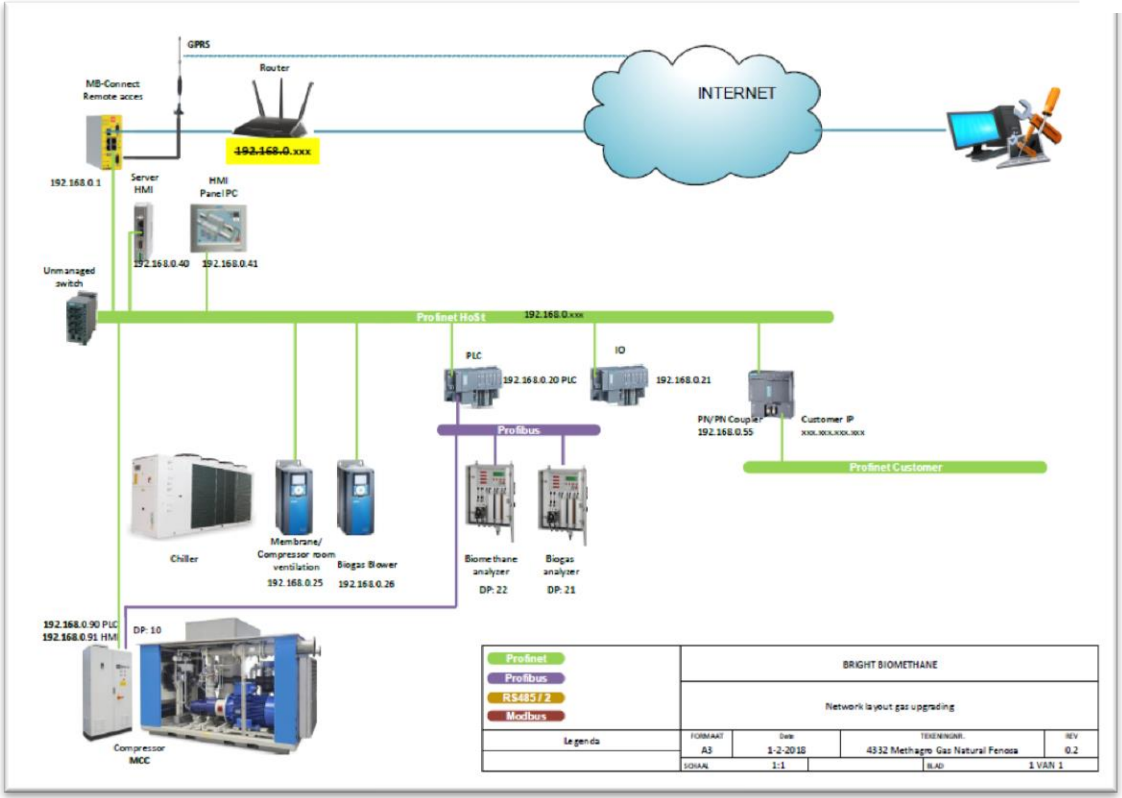
# E. CASES STUDIES. Methamorphosis Project

## DETAIL ENGINEERING



# E. CASES STUDIES. Methamorphosis Project

## DETAIL ENGINEERING



# E. CASES STUDIES. Methamorphosis Project

nedgia
Grupo Naturgy

## METHAGRO Upgrading Construction and Assembly

# E. CASES STUDIES. Methamorphosis Project


Upgrading plant constructed by Bright Biomethane with a capacity of 214 $Nm^3/h$ of BG resulting in a production of 100-135 $Nm^3/h$ BM. Plant includes a pretreatment process (3 carbon filters, drying sistem and the blower) and the Membrane unit with 19 membranes fed by a BG compressor (16 barg) manufactured by ADICOMP.

# E. CASES STUDIES. Methamorphosis Project

- *Stage* 1: 5 MEMBRANES
- Stage 2: 8 MEMBRANES
- Stage 3: 6 MEMBRANES

# E. CASES STUDIES. Methamorphosis Project


BIOGAS COMPRESSOR

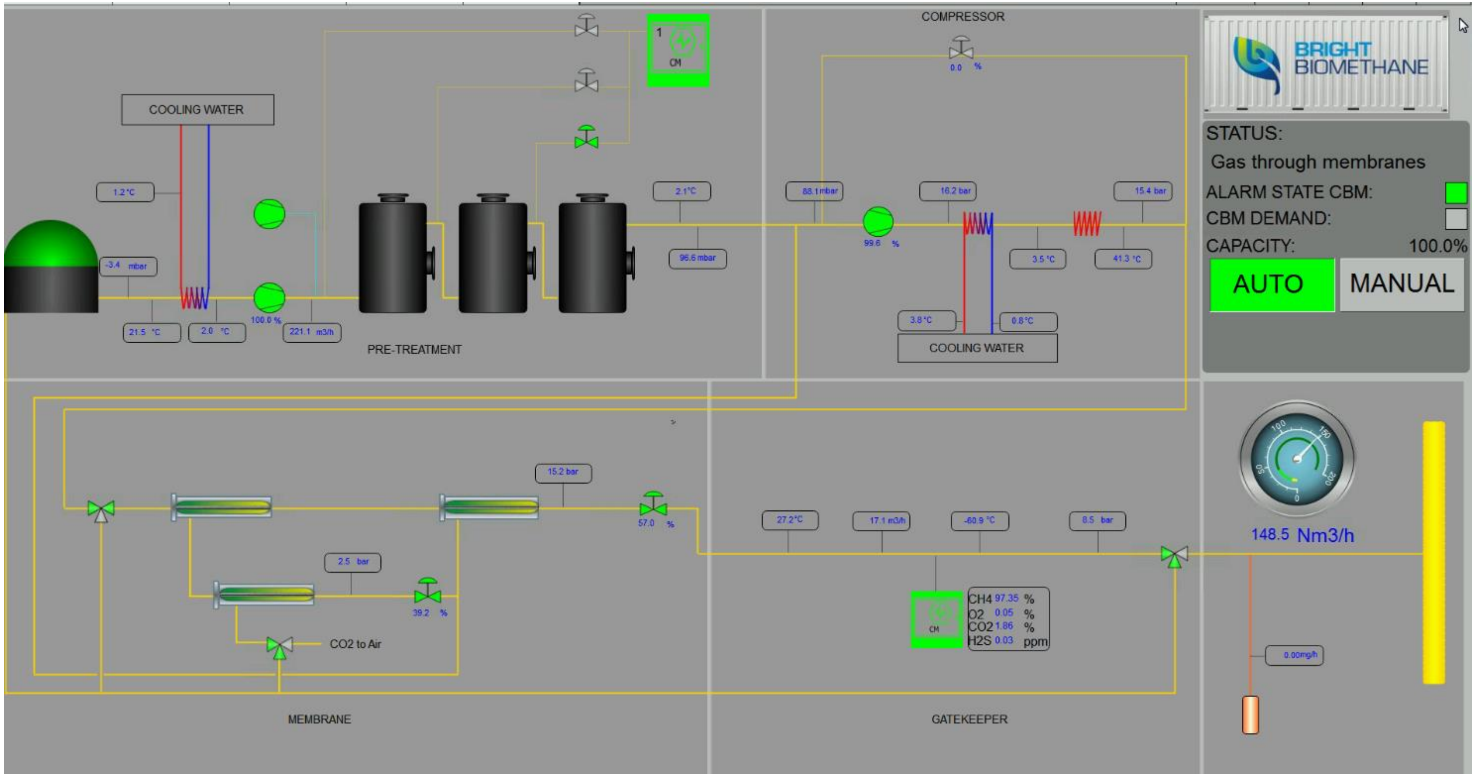
# E. CASES STUDIES. Methamorphosis Project

Gas refuelling station supplied by GASECO.

- 14 bottles x 80 l
- Compressor for 18 Nm3/h (SAFE)

# E. CASES STUDIES. Methamorphosis Project

Continuous monitoring: PLC + SCADA



# E. CASES STUDIES. Elena landfill (in construction)

It promotes the use of renewable energies. It contributes to the security of sup

# E. CASES STUDIES

nedgia
Grupo Naturgy

## CONCLUSIONS

- Biomethane is a key energy in the decarbonization
- It promotes the use of renewable energies
- It contributes to the security of supply and energy independence
- It improves the environmental management of organic waste
- Generates synergies with the agri-food industry
- Supports rural development, job placement and population in agricultural settings.

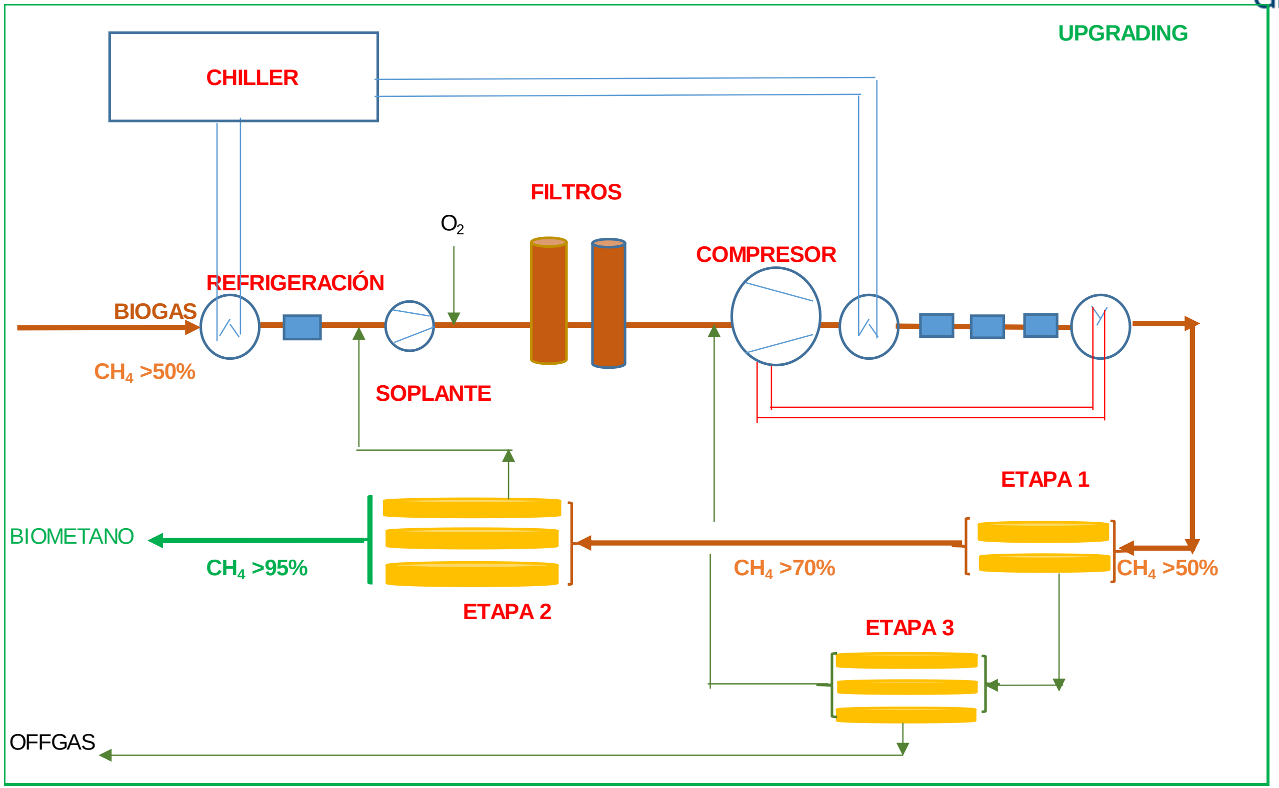
# Thank you for your kind attention!

Carmen Guinea Valle

cguinea@nedgia.es

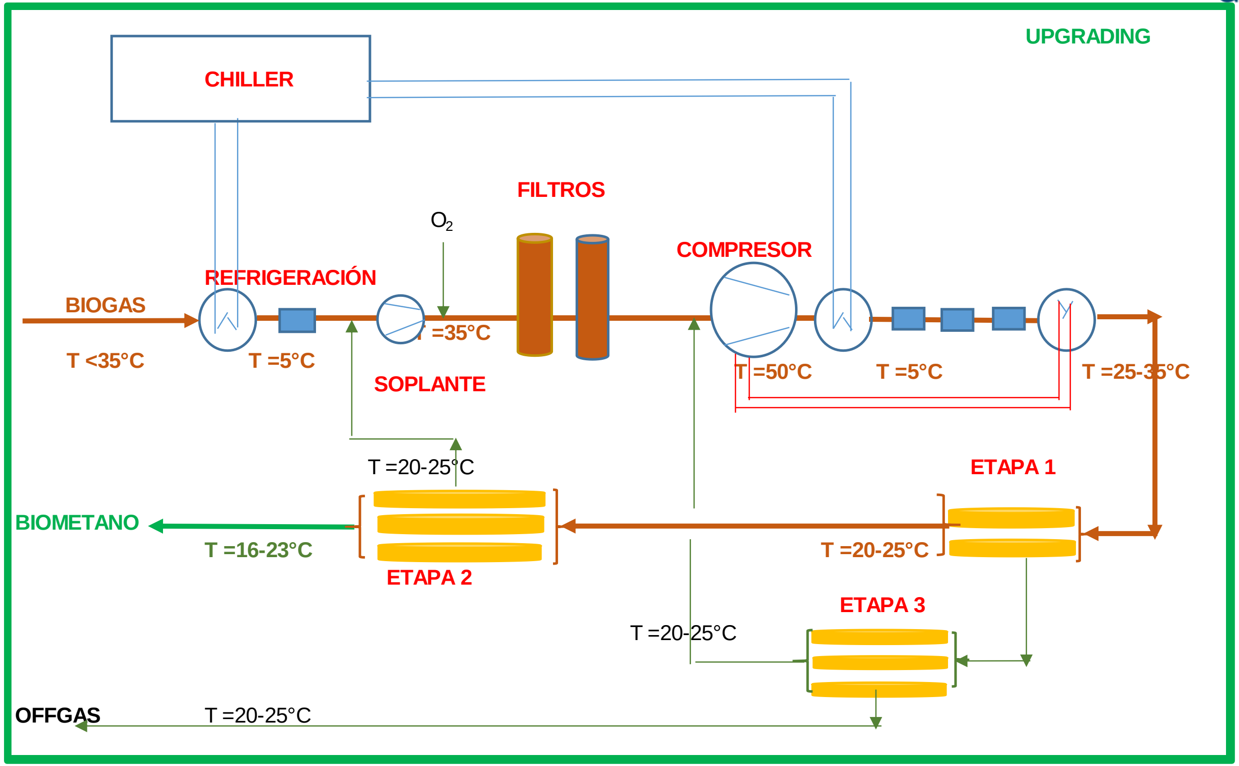
# E. CASES STUDIES. BENS Project

## Variación de la concentración de CH4



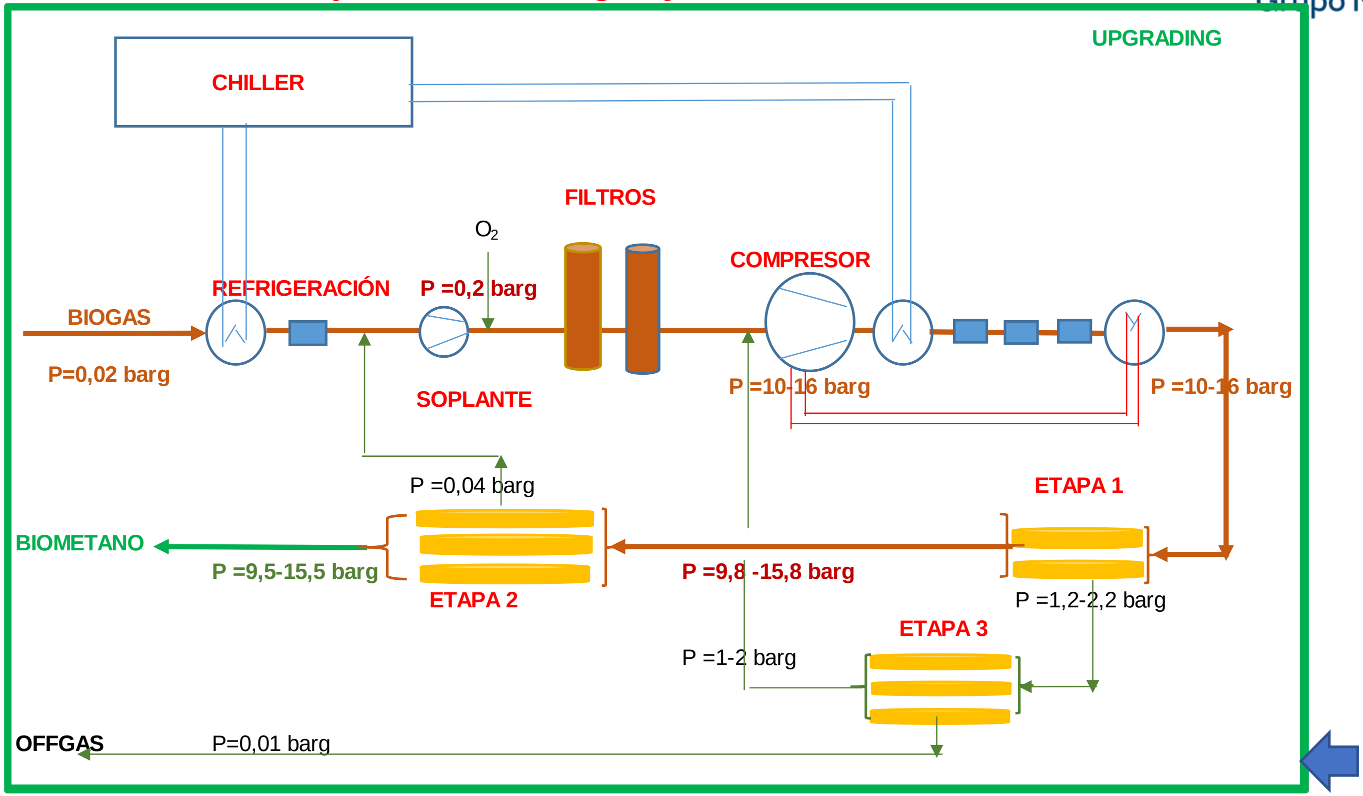
# E. CASES STUDIES. BENS Project

## Variación de la temperatura del Biogás y Biometano



# E. CASES STUDIES. BENS Project

## Variación de la presión del Biogás y Biometano



# E. CASES STUDIES. BENS Project

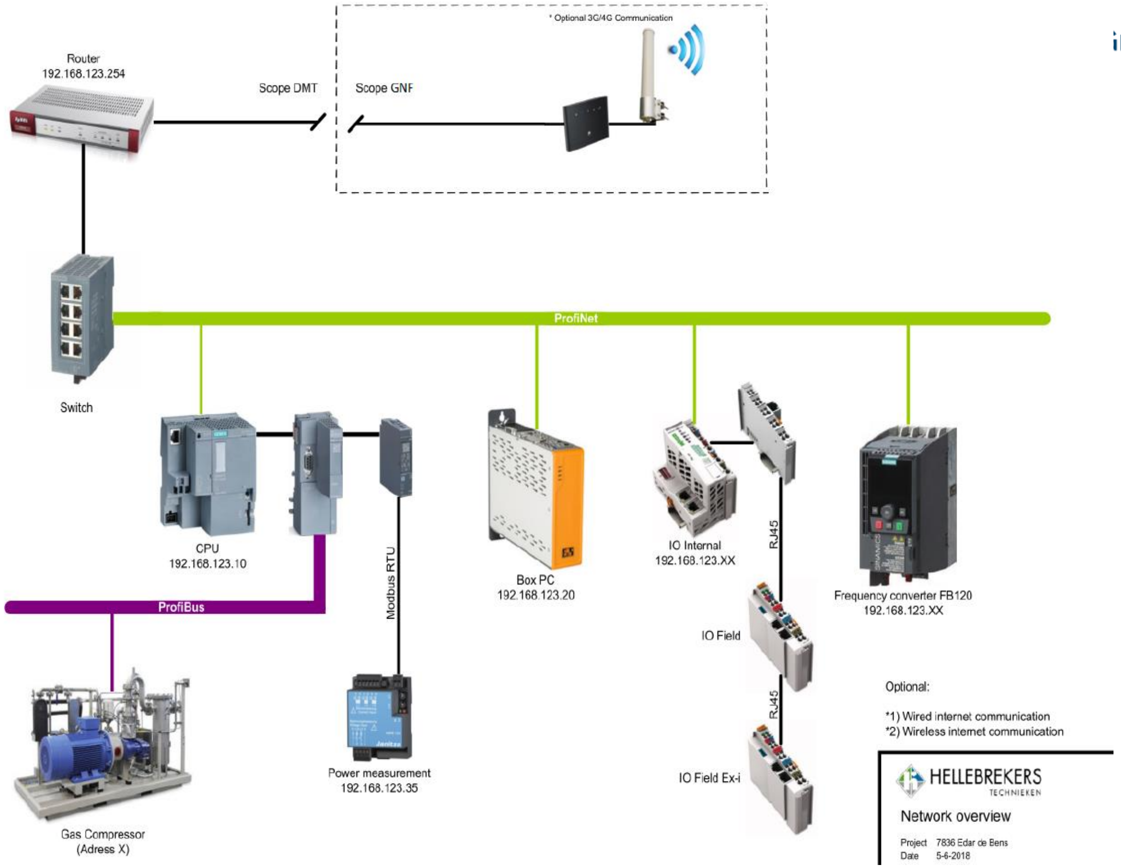
# E. CASES STUDIES. BENS Project

# E. CASES STUDIES. BENS Project

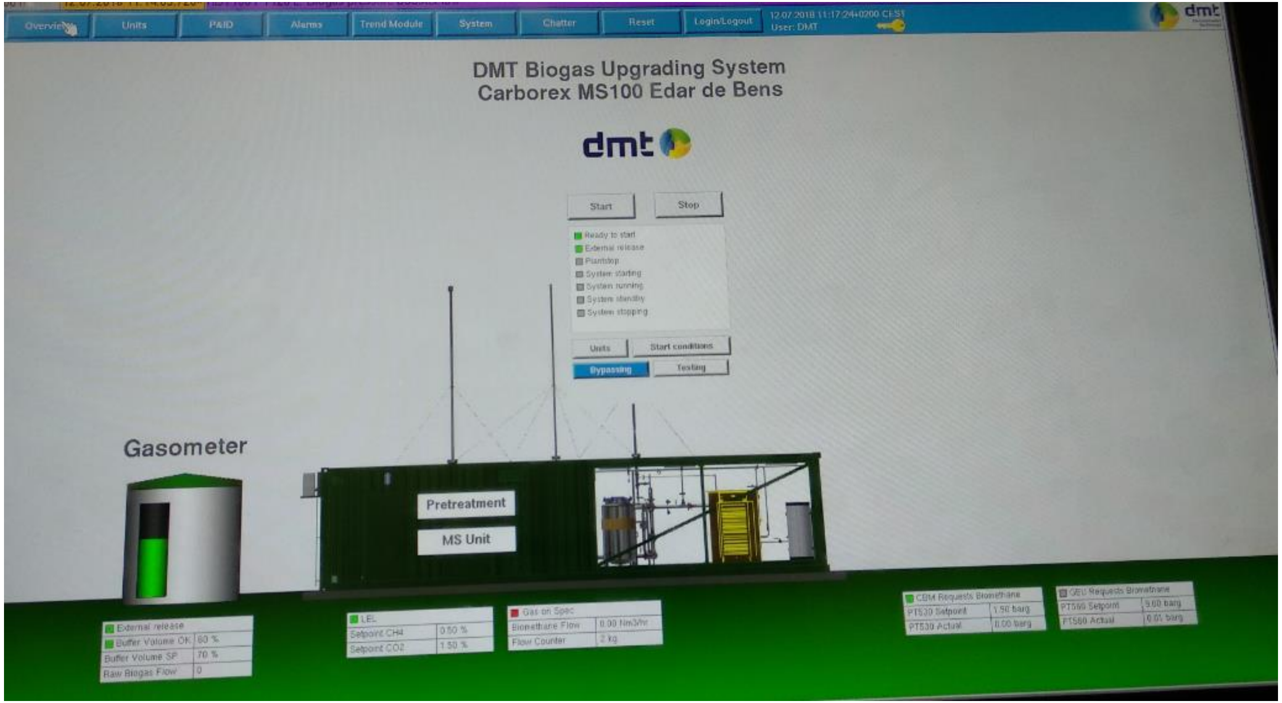

# E. CASES STUDIES. BENS Project

# E. CASES STUDIES. BENS Project

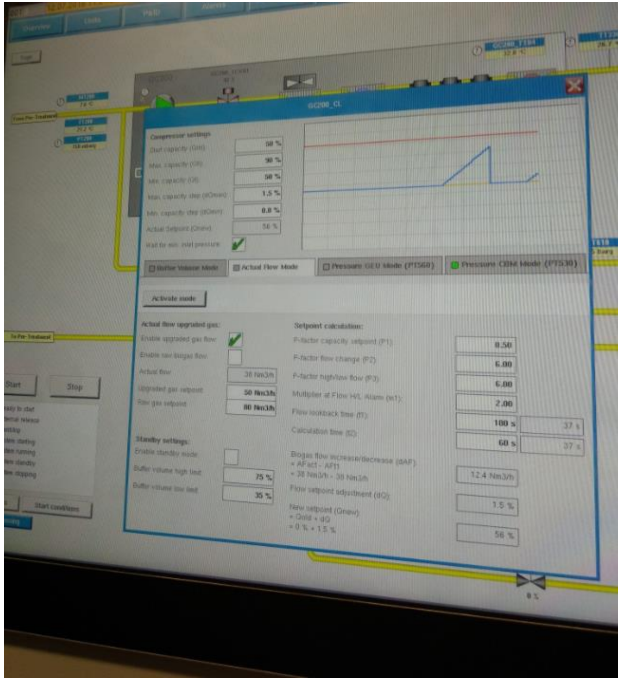
# E. CASES STUDIES. BENS Project

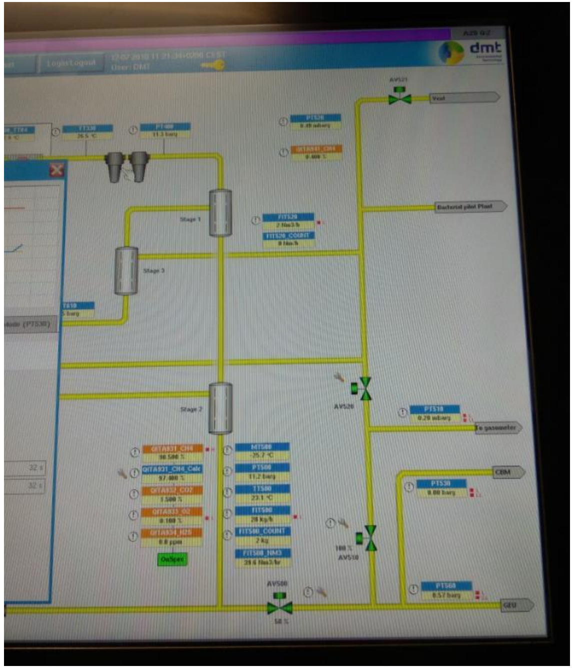


# E. CASES STUDIES. BENS Project



# E. CASES STUDIES. BENS Project



# E. CASES STUDIES. BENS Project

ADOS 401

| Details apply, per control unit | |
|---|---|
| Sensors: | Electrochemical sensors<br>Infrared sensors |
| Sensor input: | 2-wire sensors (TOX 592) or<br>3-wire sensors (GTR 196)<br>for warning of explosive<br>gas mixtures |
| Sensor supply: | 24 V DC / 200 mA max. |
| Test ranges: | $CO_2$: 0-50 Vol.%<br>$CH_4$: 0-100 Vol.%<br>$O_2$: 0 - 21 Vol.%<br>(optionally continuous)<br><br>$H_2$: 0-2 Vol. %<br>$H_2S$: 0-50 ppm ... 0-5.000 ppm<br>(only discontinuous)<br>other ranges by request |
| Accuracy: | < ±3 %, f.s.d. |

# E. CASES STUDIES. BENS Project

nedgia
Grupo Naturgy


**Model:** INCA3011-T145-01:

Analyser for Biogas measurement of
0-100 Vol% Methane CH4 (NDIR) ± 1% FS[1], continuous
0-10 Vol% Carbon dioxide CO2 (NDIR) ± 1,5% FS[1], continuous
0-25 Vol% Oxygen O2 (electrochemical) ± 0,2 vol%, continuous
0-100 PPM Hydrogen Sulphide H2S (electrochemical) ± 3ppm, discontinuous

- Autocalibrado diario en automático con botellas de gases patron para mantener precision de la medida.
- Purga de las celdas cada 6-24 horas.

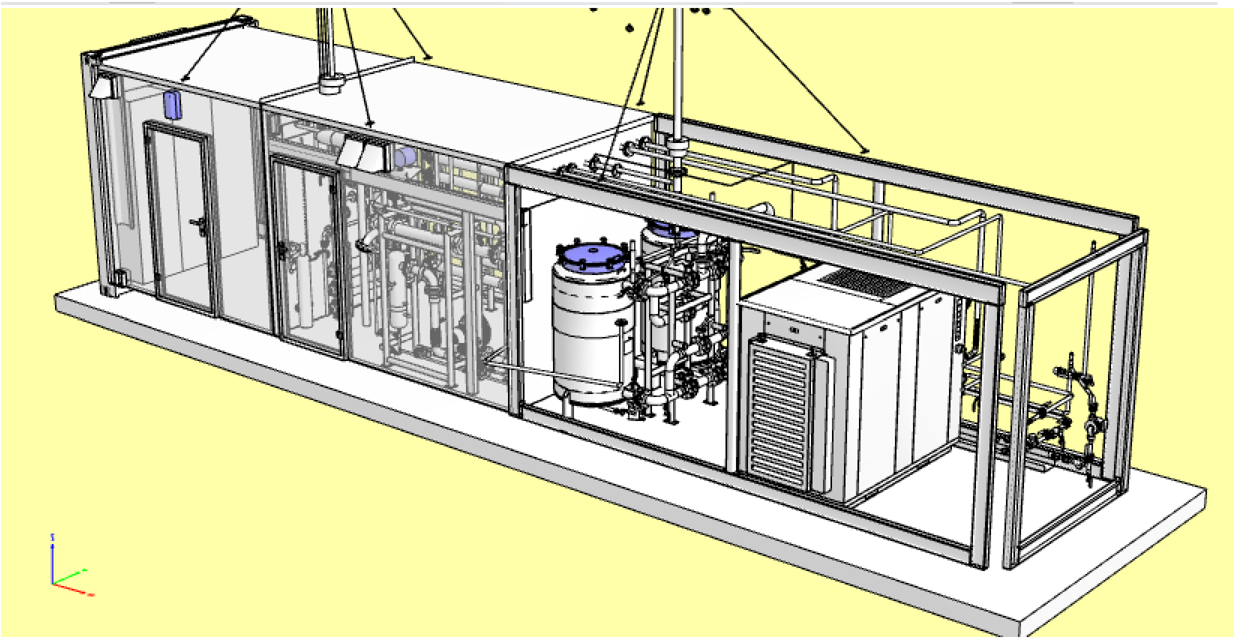
# E. CASES STUDIES. BENS Project

nedgia
Grupo Naturgy

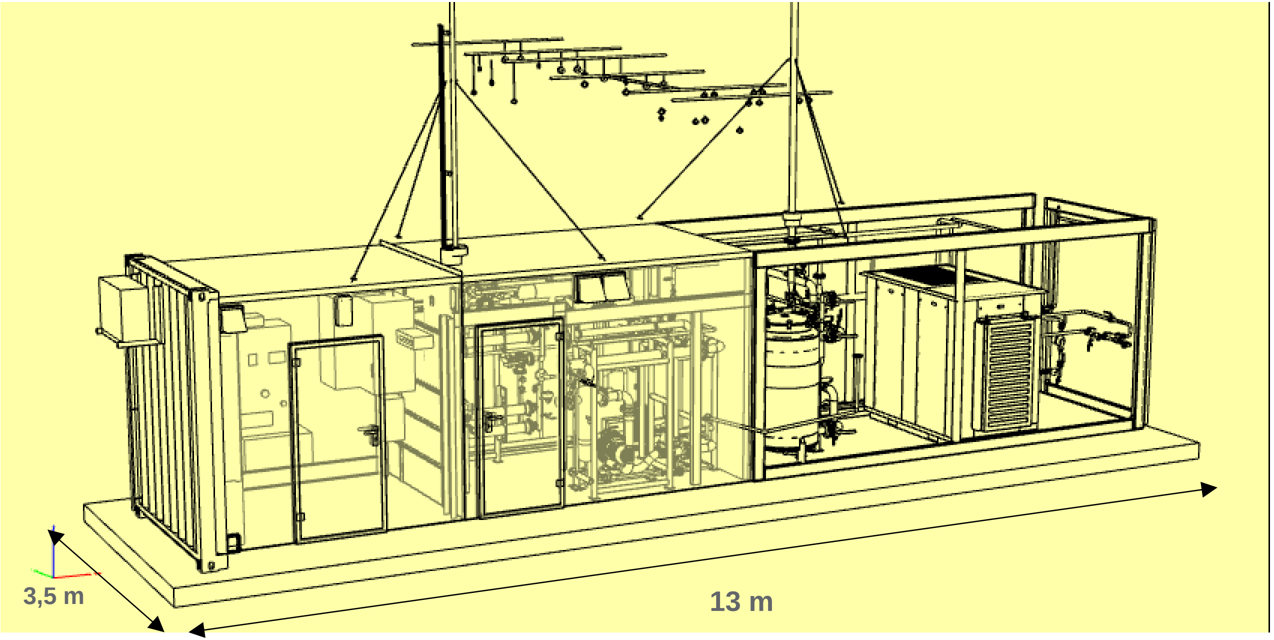

**MICHELL: EASIDEW PRO XP**

| PERFORMANCE SPECIFICATIONS | EASIDEW PRO XP |
|---|---|
| Rango de medida | -110 a +20ºC dew point |
| Precisión | ±1ºC dew point (+20ºC y -60ºC) |
| Tiempo de respuesta | 5 min to T95 |
| Repitabilidad | 0,5ºC dew point |

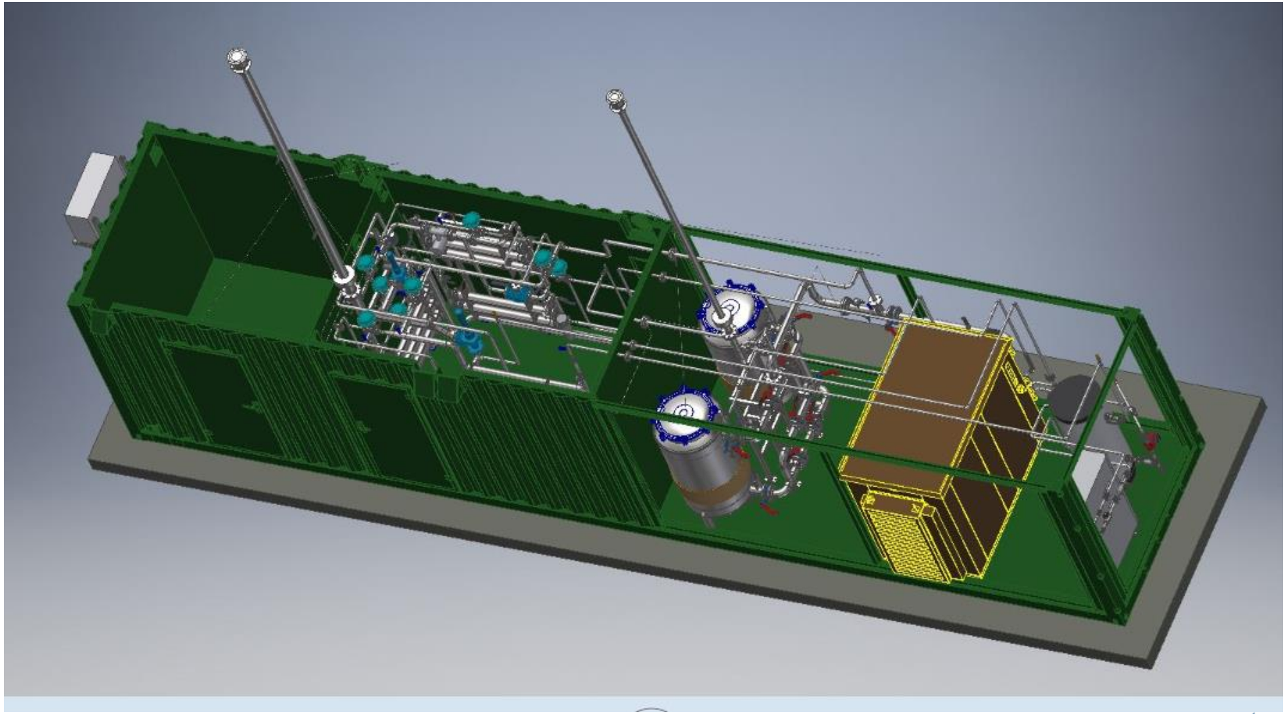
# E. CASES STUDIES. BENS Project



# E. CASES STUDIES. BENS Project



# E. CASES STUDIES. BENS Project



# E. CASES STUDIES. BENS Project

# E. CASES STUDIES. BENS Project

# E. CASES STUDIES. BENS Project

# E. CASES STUDIES. BENS Project

nedgia
Grupo Naturgy

# E. CASES STUDIES. BENS Project

# E. CASES STUDIES. BENS Project

# E. CASES STUDIES. BENS Project

# E. CASES STUDIES. BENS Project

# E. CASES STUDIES. BENS Project

# E. CASES STUDIES. BENS Project

# E. CASES STUDIES. BENS Project