Statement of Verification

EU Environmental Technology
Verification pilot programme

Technology:	BIOCAT® process for bio methanation of CO_2 into CH_4
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Verification Body		**Proposer**	
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INSP Reg. Nr. 9099
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Verified according to the ISO Standard 14034 on Environmental Management:
Environmental Technology Verification Statement of Verification is available at:
https://ec.europa.eu/environment/ecoap/etvg

This Statement of Verification summarises the main results from the verification of BIOCAT®.

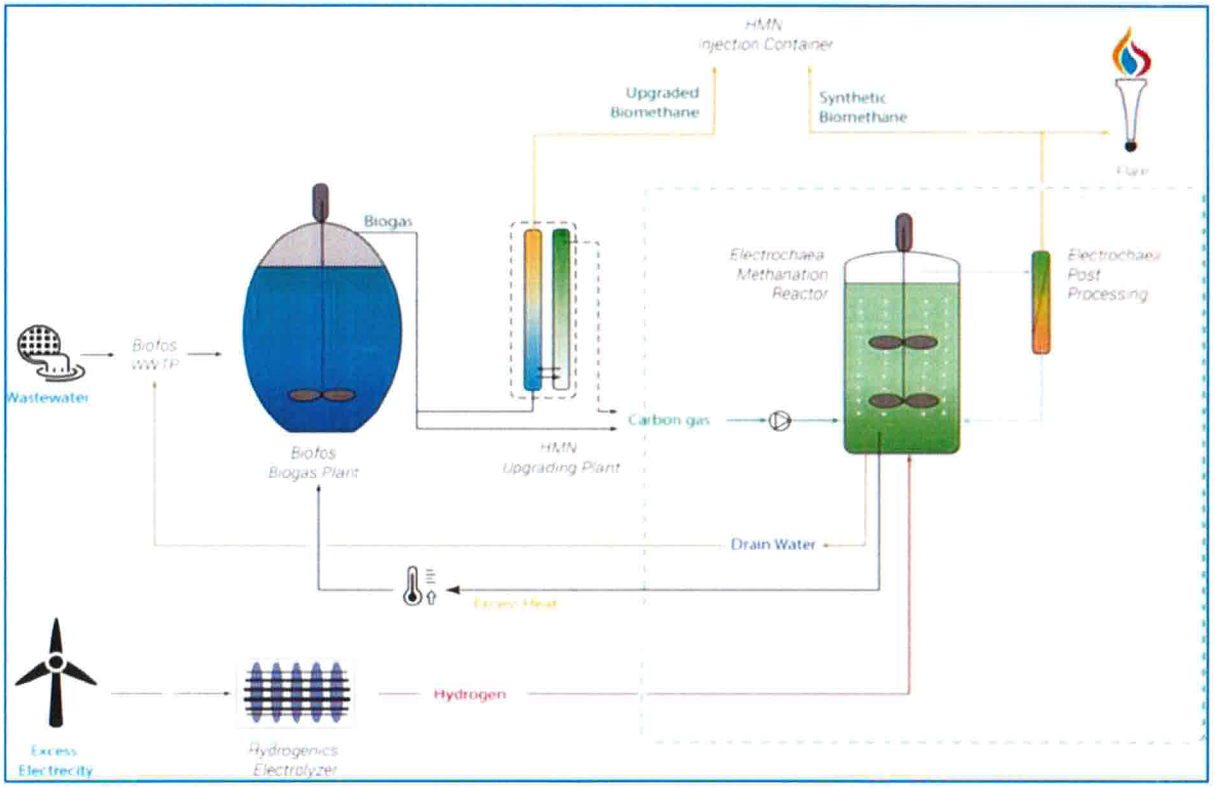
The verification was performed under the EU Environmental Technology Verification (ETV) Pilot Programme. The EU ETV Pilot Programme was established to help innovative environmental technologies reach the market by providing a framework for independent evaluation of the performance of such technologies.

This verification was undertaken by the Danish verification body, ETA-Danmark A/S. ETA-Danmark is accredited by the Danish Accreditation body, DANAK, according to EN 17020 for performing environmental technology verifications. This Statement of Verification is available on the website of the EU ETV Pilot Programme: http://iet.irc.ec.europa.eu/etv/verified-technologies

1 TECHNOLOGY DESCRIPTION

The BIOCAT® technology subjected to the ETV is a bio-methanation unit, where CO_2 and H_2 is converted to CH_4 and water in a microbial process ($CO_2 + 2H_2 => CH_4 + 2H_2O$). The BIOCAT® technology includes the whole plant to proceed a CO_2 rich gas, e.g. from a biogas plant or a biogas up-grading plant into methane, by using an H_2 rich gas, either produced by electrolysis in a separate unit or delivered from an industrial process.

Figure 1. Sketch of main parts of the BIOCAT® technology with delimitations of the ETV test with dotted line.



The unit for delivery of H_2 is not an integrated part of the BIOCAT® and it not covered by the ETV.

The BIOCAT® technology has a fast respond to operational variations and can switch from zero to full production in very short time, and vice versa. This makes it suitable for converting CO_2 into high-value CH_4 fuel, during periods of surplus production of electricity at low prices.

2 APPLICATION

2.1 Matrix

The matrix is CO_2 and H_2 gas dissolved in water at app. 60 - 65°C in a pressurized vessel up to 9 bars.

2.2 Purpose

To convert dissolved CO_2 and H_2 into CH_4 and water in a microbial process.

2.3 Conditions of operation and use

The BIOCAT® technology can convert feed streams of 100 % CO_2, e.g. from a unit to upgrade biogas for injection in the natural gas grid, or biogas with 20 – 40 % CO_2, and up to 1000 ppm hydrogen sulphide into methane. The H_2 can be delivered from an electrolysis unit, as in the test plant, or from any other processes with excess H_2 of enough purity.

2.4 Verification parameters definition summary

Concentrations of CH_4, H_2, CO_2 and H_2S in the produced gas by converting of feed streams of 100% CO_2 or biogas with 20 - 40% og CO_2 and up to 1.000 ppm H_2S, measured with an in line AWITE gas analyser.
Capacity of CO_2 converted per m^3 reactor liquid volume above the gas injection point and quantified by the ratio of reacted CO_2 against the total amount of reacted and non-reacted CO_2 in the product gas.
Net electricity consumption per Nm^3 of CH_4 produced with a CO_2 flow of 20 Nm^3/h and the specified gas quality, measured as the total consumption of the plant.
Water production measured over a period with steady and stable operation, calculated by the increase of the water level in the reactor (which periodically is drained).
Overall heat exported from the reactor by cooling water in kWh per Nm^3 of CH_4 produced.
Operational performance and capacity are calculated and documented by the level and variation in several parameters, especially the CO_2 and H_2 flows and the gas composition.

3 TEST AND ANALYSIS DESIGN

3.1 Existing and new data

No existing data has directly been used for the verification, but existing data has formed the basis for determination of the operational capability of the BIOCAT and the corresponding claims.

3.2 Laboratory or field conditions

The verification test was performed at the BIOCAT® test plant located at BIOFOS Spildevandscenter Avedøre A/S in Copenhagen, Denmark. The test was operated by the BIOCAT staff who secured the raw data and operation of test equipment. During the test period the test responsible visited the test facilities unannounced to make spot checks on data consistency and operation according plans.

3.3 Matrix compositions

The matrix composition is the operation of the whole plant, where all data from instrumentation in/output is registered, and data is logged in the plant control system. All data has been available for the validation test.

3.4 Test and analysis parameters

The test has not included any measurements, sampling or analyzes carried out by the test body, as the test was performed in the same way as a CO_2 verification by approved personnel and in accordance with the EU guidelines for CO_2 verification.

3.5 Tests and analysis methods summary

Prior to the verification test, the verification has among other things included:

- A strategic analysis carried out for an overview of the plant
- A risk assessment carried out for prioritizing efforts
- Assessment of the competences of staff on the task

In complete analogy with the CO_2 verification procedures, the verification test itself includes:

- Line walking; inspection of processing plants, instrumentation, sampling points, etc.
- Assessment of the suitability of measuring agents (calibration status, accuracy).
- Assessment of data flow, calculations, and IT system.
- Assessment of procedures (e.g. for calibration, deviation management, etc.).
- Assessment of uncertainty budgets.

The plant was operated by the BIOCAT staff according to test plans who secured the raw data and operation of test equipment. During the test period the test responsible visited the test facilities (unannounced) to make spot checks on data consistency and operation according plans. After tests the BIOCAT operators collects data representing each of the claim. All data in each period claimed to test the validity of the claims was present for data analyses.

3.6 Parameters measured

The main parameters used from the data logged in the plant control system are: Gas composition (CH_4, CO_2, O_2, H_2S), flows of CO_2, H_2 and produced gas, overall electricity consumption and produced amount of water.

Secondary parameters used for calculations and to correct the main parameters to the reference conditions are temperatures pressures, cooling water flow etc.

4 VERIFICATION RESULTS

The ETV test has documented the BIOCAT® system's performance in relation to gas quality, capacity, energy consumption and operating conditions with the following results:
The nominal operation corresponds to the supply of 18 Nm^3/h of CO_2 and the Hydrogen flow necessary to achieve a gas quality observed in the reactor outlet of at least 95% CH_4 and less than 1% CO_2.

Operational capabilities:

1. The BIOCAT® produced gas fulfils the following quality specification by normal steady state operation:
    a. > 95%Vol. CH_4
    b. < 4%Vol. H_2
    c. < 1%Vol. CO_2
    d. < 5 mg/Nm^3 H_2S

This gas quality is assumed to be complied with in relation to the following claims.

2. The capacity of CO_2 per m^3 reactor liquid volume was 150.7 ±2.4 $Nm^3/m^3/day$ with pure CO_2 as feed gas and 153.5 ±3.3 $Nm^3/m^3/day$ with raw biogas.
   150 $Nm^3/m^3/day$ corresponding to a CO_2 load of appr. 19.8 Nm^3/h.
3. The nominal operational range for CO_2 load is 11 to 25 Nm^3/h. The tests have mainly included CO_2 loads from 15 to 20 Nm^3/h hours, and only a few tests with CO_2 loads greater than 20 Nm^3/h,
4. Electricity consumption is measured to be 24.2 ±1.5 kWh/Nm^3 of produced CH_4, for a CO_2 load of 20 Nm^3/h.
5. Overall heat exported is measured to be 6.58 ±0.07 kWh/Nm^3 of produced CH_4.

The actual achieved figures in claims 4 and 5 can deviate depending on the outdoor temperature and chill factor.

6. Water production is 1.6 ±10% kg/Nm^3 of produced CH_4, measured over a period of six hours.

A series of test with start/stop and idling with and without maintaining vessel temperature and pressure the BIOCAT® plant, has demonstrated the following dynamic operational performances and capacities:

7. The CO_2 load can be increased with a ramping rate of 1 $Nm^3/h/min$.
8. The BIOCAT® can be stopped in less than 1 minute.
9. The BIOCAT® can be stopped and stay idle without energy input for 2 hours and then restart with a CO_2 load of 15 Nm^3/h in 15 minutes.
10. The BIOCAT® can remain in dormant status for up to 30 days and ramp to full production with a CO_2 load of 18 Nm^3/h within less than 12 hours, after reheating the reactor to the operational temperature of 60°C.

5 ADDITIONAL INFORMATION, INCLUDING ADDITIONAL PARAMETERS

No additional information or additional parameters has been identified during the test.

6 QUALITY ASSURANCE AND DEVIATIONS

The quality of the verification test and the data retrieved from the plant where controlled as described in the Verification Report and in the Test Report.

A test system audit was performed by ETA-Danmark during the tests at the BIOCAT® test plant located at BIOFOS Spildevandscenter Avedøre A/S on October 28th, 2020.

Since ETV is performed as a performance test during normal operation with planned variations, following the same principles as a CO_2 verification, there has only been a plan for operation of the plant, with different types and loads of CO_2 feed gas and operational variations, and there have been no direct changes or deviations from it. However, in the evaluation of the test results, it has been found that one of the original claims related to plant restart capability was redundant and not required. Therefore it has been removed from the verification.