Centro Tecnológico de Eficiencia
y Sostenibilidad Energética

Technical specifications to govern the contract of the "Engineering and assembly service of a dark fermentation reactor for the production of biohydrogen" to be awarded by simplified open procedure within the framework of the UNIDADE MIXTA DE GAS RENOVABLE project

UNIÓN EUROPEA

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1 Objective

The purpose of this document is to establish the minimum technical conditions to be met by the ***$BioH_2$ production system***, hereinafter referred to as the **System**, for its installation in EnergyLab's laboratory.

The basis of this system is the production of $BioH_2$ from the biological decomposition of organic waste. This anaerobic decomposition generates, under the appropriate operating conditions, **H_2** and other gases such as **CO_2** or **CH_4**.

The reactor design will be based on a **continuous stirred tank reactor (CSTR)**, which will be fed with different wastes to evaluate the potential for $BioH_2$ production.

2 Design and supply of the equipment

The **design and supply** of the necessary equipment is required for the construction and assembly of the System at EnergyLab's facilities, including the preparation and delivery of all the documentation required by the current legislation in force in Spain and the specifications of this document.

The equipment and systems lided by this contract are described below, as well as the **minimum requirements** that must be met. In case of non-compliance with these requirements, the offer will be considered non-valuable.

2.1. General description of the equipment and systems to be contracted

The scope of this bid lids the **following tasks**:

- The **design and construction** of the $BioH_2$ production reactor.
- The **supply of the necessary equipment for operation**:
  - **CSTR** type reactor of **20-25L** total volume with useful volume of 18-23L.
  - **Feeding system** (influent) and extraction of culture media/digestate (effluent).
  - **Temperature measurement and control** system.
  - **pH measurement and control** system.
  - **Flow rate measurement and H_2 content analysis** system.
  - **Agitation** system.
- The **physical support** for the reactor and all auxiliary material (racks, pumps, flow meters, valves, piping, connections, calibration, fastening and wiring systems).
- The supply of **manuals** and all the necessary documentation for the correct operation and maintenance of the equipment (installation, operation and maintenance manuals, manufacturer's information/contact details, waste management, warranty, etc.), preferably in **Spanish**.
- **Maintenance and guarantee** of the correct operation of the System, for a period of at least one (1) year.

As an example, a general scheme of the system and the technical requirements to be offered is shown in the following figure.

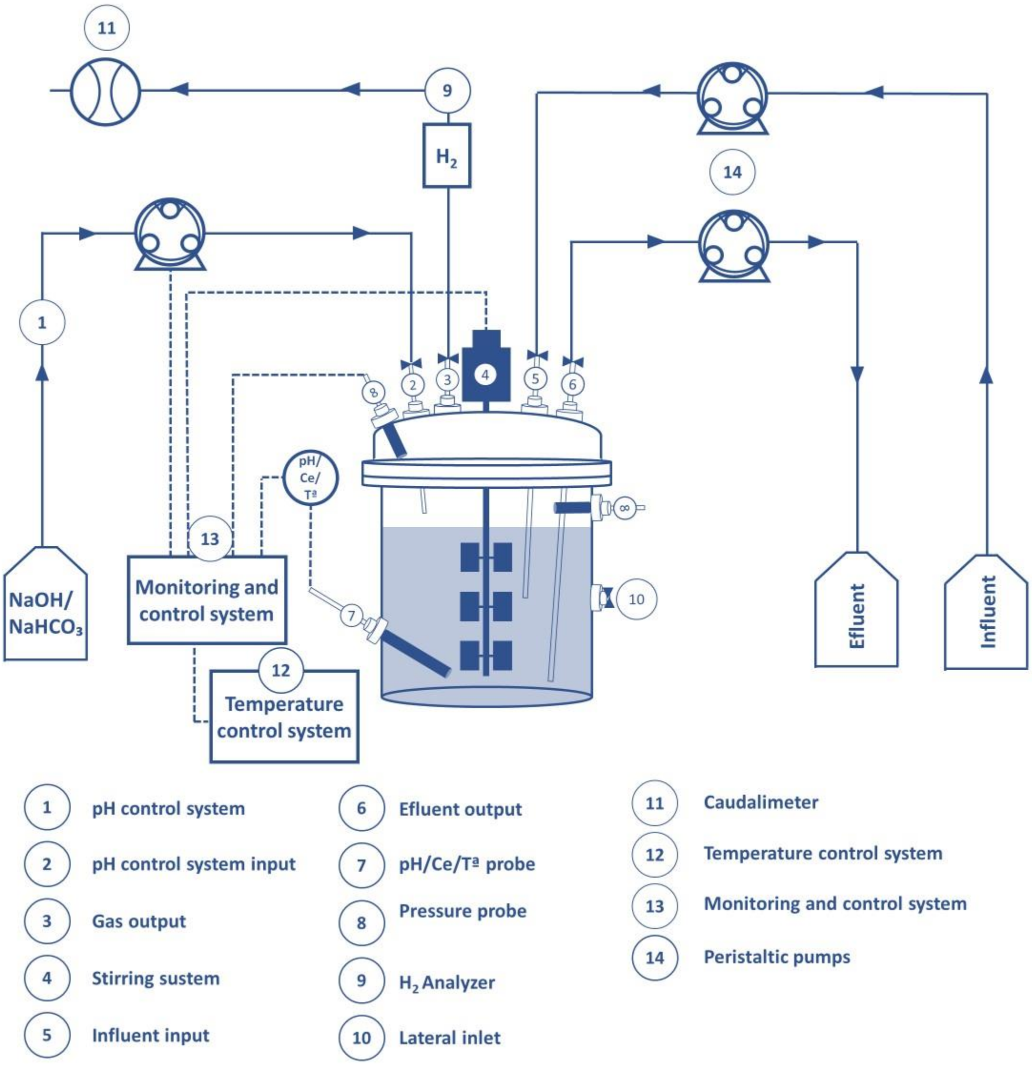

Figure 1. General scheme of the system (this is an example). If the reactor lidlid is overloaded with too many ports, the pressure probe, ⑧, may be located in the reactor body.

The laboratory space where the system will be located is limited. Therefore, bids will be evaluated positively if the requested system is as compact as possible, approximately **1-1.3 m^2** and does not exceed a maximum height of **1.8m**.

2.2. Fundamental technical requirements

2.2.1. Reactor body and lidlid

The reactor shall consist of a **cylindrical body** of borosilicate glass or stainless-steel that guarantees the **anaerobic** necessary **conditions** for the BioH_2 production process. Regarding the technical requirements, the reactor must be able to be operated under the following conditions:

- Working at different temperature ranges
  - Mesophilic 25-40 ºC
  - Thermophilic 40-60 ºC
- The reactor will be operated with hydraulic residence times (HRT) between 2 hours and 30 days (flow rates between **4 and 12 L/h**).

The reactor must have a volume between **20 and 25 L** (which will allow working in a range **of 18 to 23 L** of useful volume). Regarding the dimensions, small variations in size that not exceeding 10% of those indicated may be admitted provided that this is indicated in the offer. In addition, it is mandatory to have **level marks** in order to determine the work volume. In case of metallic material, the reactor must have a transparent section of its surface to see the interior. The dimensions of the reactor must be at least:

- Total diameter: 0.30-0.40 m
- Height: 0.20-0.35 m

The reactor body must have:

- Inlet for the **pH / Temperature probe**, guaranteeing contact with the internal liquid regardless of the minimum working level (10 cm above the base).
- Accessory inlet at a height between 7 and 10 cm from the base.

The **lid**, which can be opened, must allow the system to be **hermetically sealed** with the reactor body and may be made of glass or stainless steel. It should have about 6 independent opening ports with a sealing system that guarantees the tightness, as shown in Figure 1 (although another proposal may be accepted, such as the entrance of a sensor through a side wall of the reactor). More specifically, it will be required:

1. An inlet for the introduction of the **pH control buffer**.
2. An inlet for the **gas outlet**.
3. An inlet for the **mixing motor shaft**.
4. An inlet for the influent/feed inlet, diameter approximately **4 cm** and having an inner pipe in contact with the liquid to avoid gas losses.
5. An inlet for the **effluent** outlet with a pipe long enough to maintain 10 cm to the base of the reactor.
6. An inlet for the **pressure sensor** of the gas that accumulates in the headspace. In case of an overload of nozzles in the lid, the entrance of this sensor could be located on the side of the reactor body, always guaranteeing the contact with the gas phase regardless of the maximum working level.

In the event that a lid with all 6 openings cannot be supplied, a solution with fewer entrance than indicated will be valid if the supplier guarantees that the functions described can be fulfilled with fewer openings and, thus, the cost of the reactor can be reduced.

The lid outlets shall be provided with a **connector system** to make connections to piping. The **diameter of the outlets may be variable** and may not be the same for all of them if the feasibility of the connections is guaranteed. Also, when the outlets are not in use, they must be able to be closed by means of valves or plugs, guaranteeing the watertightness of the system.

It is important to consider, for the design of the lid and reactor body, that the system must be able to be operated at **negative pressures** of around -100 mbar below atmospheric pressure (working pressure of 900 mbar) and at **positive pressures** of approximately +500 mbar, so that the final working range would be 900-1500 mbar.

2.2.2. Reactor heating system

To achieve constant temperature operation, it will be necessary that the reactor has a **heating system** to reach the temperatures indicated in section 4.2.1. One of the following systems is acceptable:

- By means of a **thermal bath**. This mechanism will require that the reactor body has a **watertight external jacket** through which water circulates at the temperature set by the set-point of the thermal bath.
- By means of an **electric heating jacket**. This heating jacket should lid the reactor, leaving a portion of unlided surface, large enough to be able to visualize the contents of the reactor.
- **Other reactor heating options** may be accepted if homogeneous heating of the interior contents and the requested temperatures are ensured.

In addition, the bid must include the necessary **piping and valves** and fittings to operate the system at the indicated temperatures **(25-60ºC).**

2.2.3. pH measurement and control system

The system must have pH **measurement and control** equipment to maintain the pH at stable values set in the monitoring and control system. The pH control shall consist of at least one peristaltic pump that allows the dosing of buffer from a reservoir for pH adjustment.

2.2.4. Pressure measurement system

The system shall be equipped with a **pressure measuring probe** to determine the working pressure, range from -100 mbar to +500 mbar (900-1500 mbar).

2.2.5. Feeding and digestate disposal system

The reactor's influent feed and digestate (effluent) removal system must allow the system to operate under **continuous** and **semi-continuous** (Fed-Batch) conditions. For this purpose, the system must have **two peristaltic pumps** (one for the influent feed and the other for the digestate removal). These pumps should generate flow rates between **4 L/h (32 mL/h) and 12 L/h**.

In cases where the waste is solid or semi-solid (organic debris, garbage) EnergyLab will install a **linear actuator or similar**. Therefore, is important that the supplier of the System considers that the feeding inlet should has a **wide diameter** of at least 4 cm**.**

The bid should also include the necessary **piping and connectors** for the proper operation of the influent feed and digestate disposal system.

2.2.6. Mixing system

The agitation system should consist of a **vertical mechanical stirrer with rod or helix** that guarantees the complete homogenization of the culture medium. It must allow a complete mixing considering the working volume of the reactor of between 18 and 22 L and the nature of the reactor content. The stirring motor must have a display screen and a rotation speed (rpm) regulation system.

2.2.7. Gas measurement system

The system shall have an equipment to measure the gas generated (volume and composition) in the process. For this purpose, the reactor lid shall have a gas outlet connected to:

- A **flowmeter** allowing volumetric measurement of the gas.
- H_2 percentage **analyzer** in the gas (expected between 0-50%).

2.2.8. Electrical installation, electrical and control panel

The bid shall include the **supply of an electrical panel for control, protection and monitoring of the complete equipment of the System**, including its assembly and wiring, as well as the supply and assembly of conduits and electrical cables necessary for the electrical installation and connection of the equipment requested in this document. This electrical panel will be connected to the general electrical panel.

The variables that at least have to be monitored and controlled continuously (with the exception of the gas measurements that can be punctual, but it is necessary to indicate the frequency) in the System are:

1. Measurement and control of the pH in the reactor
2. Measurement of the temperature inside the reactor
3. Average pressure inside the reactor
4. Measurement of the gas outlet flow
5. Measurement of the gas composition

The system shall also record data every 15 minutes and store it. The download of the measured data should be possible (USB, SD card, network) in a Microsoft Excel compatible format.

2.2.9. Reactor fastening and support

The reactor and all the complementary elements necessary for the correct operation of the system must have a **physical support** that facilitates its correct **operation, handling, maintenance and cleaning**. This may consist of a shelf type support where all the described elements can fit.

2.2.10. System assembly and installation

The supplier company must enclose detailed assembly instructions that allow EnergyLab personnel to carry it the assembly easily, in the event that it is not carried out by the company awarded the contract.

2.2.11. Extra elements

In addition to the basic equipment, it will be **valued** that the supplied system is equipped with:

1. **Electrical conductivity (EC)** probe complementary to the pH and temperature probe.
2. The **supply of an ATEX vacuum pump** that allows working at a negative pressure of -100 mbar below atmospheric pressure with a flow rate of approximately 2.5 L/min will be a plus.
3. The inclusion of a **H_2 mass flow** controller to inert the headspace and a flow rate of 2 L/min (Figure 1) will be positively valued.
4. Continuous (or semi-continuous, with at least 1 measurement every 30 minutes) **gas composition analyzer** (CH_4, CO_2, N_2 and O_2).
5. Continuous (or semi-continuous, with at least 1 measurement every 30 minutes) **analyzer of H_2S** content (0-2000 ppm).
6. **Control SCADA** that allows to visualize in real time all the variables and to act on the different systems.
7. **Linear actuator** or some system to automate the input of solid or semi-solid feed into the reactor.
8. **A valve to avoid overpressure and underpressure**, to guarantee the structural stability of the reactor and the lid.
9. Recording of the stirring speed (rpm) and stirring frequency of the reactor.
10. Assembly, implementation of the installed system and verification of its correct operation.

2.2.12. Additional considerations

Some limitations/considerations to be taken into account are:

- The laboratory power line is **220 V and 50 Hz**.
- The total **height** of the laboratory is **3.15 m**.
- The external access and door have the following dimensions:

Figure 2. View of the accesses to the CITEXVI loading area. Entrance door.

- The **elevator** measures **115 cm (width) x 218 cm (height) x 240 cm (depth)**.

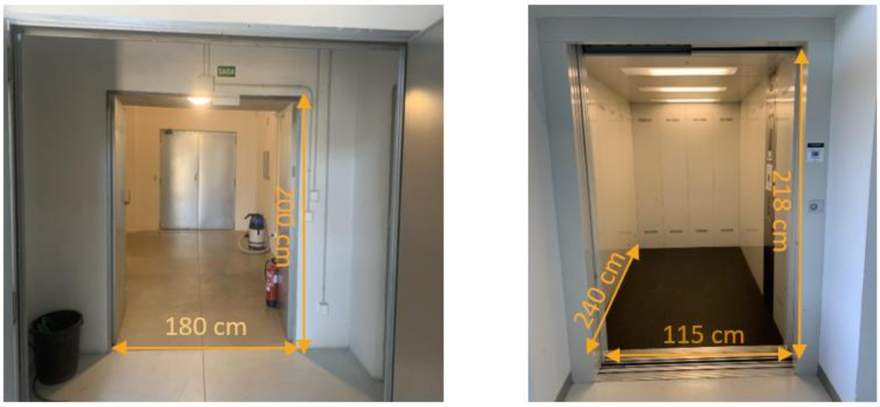

Figure 3. View of access from the second basement to CITEXVI. Cargo elevator

- It is important **to minimize the electrical contact** of the elements, since it is going to work in an environment with CH_4 and H_2.
- The material of which the reactor and the pipes that make up the system are made must be selected considering the nature of the gas generated (CO_2, H_2, CH_4, H_2S).
- The quotation must include the **shipment** of the material to Energylab's facilities.

3 Warranty

The warranty period, starting from the formalization of the Act of Acceptance of the supply, including the delivery and commissioning of the complete System, will be at **least of one (1) year** for the materials and equipment installed that are defective, without prejudice to the establishment of a longer period of time if the offer includes an improvement in the warranty period..

If during this warranty period any defect is detected in the design of any equipment and/or material component of the installation or poor quality of the materials at origin, or any malfunction of the installation, the successful bidder shall be obliged to replace the defective equipment or materials and/or to carry out the necessary work to correct these defects until the correct operation of the installation, at no cost to EnergyLab.

The warranty shall lid the electrical and mechanical parts of the System, provided that the System is properly operated, in accordance with the maintenance procedure(s) and instruction manual(s) provided by the successful bidder. Parts that may suffer wear and tear due to regular use will not be included in the warranty. Mechanical damage for which the successful bidder is not responsible shall not be included.

Regarding the components or equipment of the installations that are to be replaced or repaired, the warranty period shall begin to run again from the time of replacement.

A provisional Acceptance Certificate shall be signed upon delivery of the supply. The final Act of Acceptance shall be signed after the test run or commissioning, or up to two months after delivery or preparation of the installation for operation.

4 Delivery location

The place of delivery of the equipment will be at the EnergyLab facilities, in the CITEXVI Building, University of Vigo.

5 Minimum documentation to be submitted by bidders

The bidder shall submit, as a minimum, the following technical documentation:

A. **Technical report describing the System.**
B. **Diagrams of the assembly including measurements.**
C. **Detailed technical specifications of the equipment.**

6 Criteria for evaluating technical aspects

For the evaluation of the proposals, the EnergyLab contracting board will consider the following evaluation criteria for the improvement options introduced in the bids:

SECTION	CONCEPT	EVALUATION (MAXIMUM SCORE: 50)
Extra Elements	Determination of electrical conductivity of the reactor interior	2
	Supply of an ATEX vacuum pump with a flow rate of 2.5L/min.	4

	Supply of a 2L/min mass flow controller	2
	Continuous or semi-continuous (at least every 30 minutes) analyzer of flue gas composition (CH_4, CO_2, O_2 and N_2)	9
	H_2S analyzer in the flue gas in continuous or semi-continuous mode (at least every 30 minutes)	6
	SCADA Control	14
	Linear actuator or some system to automate the inlet of solid or semi-solid feed to the reactor	3
	To include an overpressure and underpressure valve.	3
	Recording of the reactor stirring speed.	2
Others	Compact System Layout	2
	Installation, commissioning of the system and testing of its function	1

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