



## CHALLENGE 1: REDUCE OF SULFUR IN CRUDE

**An open innovation challenge focused on reducing sulfur from crude oil produced in the Hocha, Río Saldaña, and Ibamaca fields in Tolima, Colombia.**

### Background

Hocol, a subsidiary of the Ecopetrol Group, boasts over six decades of experience in hydrocarbon production and exploration. Its operations are primarily concentrated in northern Colombia (Atlántico, Bolívar, Córdoba, La Guajira, Sucre), the Llanos region (north of Meta and south of Casanare), and the Upper Magdalena Valley (Huila and Tolima). Notably, Hocol stands as Colombia's sole company actively engaged in offshore production.

Approximately 70% of Hocol's organic production originates from fields discovered by the company itself. Hocol's strategic strengths—technical expertise, agility, sustainable cost efficiency, and proactive environmental management—underscore its competitiveness and commitment to sustainability.

Throughout its history, Hocol consistently surpasses its self-imposed goals through diligent execution:

- Collaborating closely and harmoniously with communities, contractors, suppliers, authorities, and other stakeholders.
- Adhering to clear principles of responsibility and coherence that enable us to operate in an environment of respect and reliability in our activities.
- A dedicated team with a strong sense of professionalism, commitment, and leadership.

Hocol has significantly contributed to Colombia's development and achieved remarkable milestones throughout its history. Building trust, honoring its word and its commitments, maintaining a legitimate and genuine relationship in the regions, converging with the priorities of the territories and offering its allies ethics and transparency.

As part of the territories where it is present, it seeks to be an example of harmony between the energy industry, communities and the environment, for this reason it is committed to developing its activities with a focus on sustainability, through contributing to development, sustainability of communities, the protection and promotion of environmental care, participating as a strategic ally, seeking to continually improve with the purpose of ensuring the present and future of its operations.

Hocol's Sustainable Development Strategy is supported by a systematic and



transversal model called T ESG, which includes the areas of Technology (T), Environment (E), Social (S), and Corporate Governance (G) and is aligned with the Sustainability strategy of the Ecopetrol Group, placing sustainability and technology at the heart of the business strategy and its long-term performance to advance the energy transition, meeting the goals set around energy generation, guaranteeing carbon neutrality to 2025, water positivity to 2030, social value and nature-based solutions; maintaining leadership in promoting regional development.

### Context:

The capacity for innovation and the search for greater efficiency that translates into the permanent generation of value are fundamental axes to guarantee sustainability at Hocol.

Hocol's Innovation strategy is part of the company's strategic framework that seeks to identify alternatives and solutions to achieve and exceed business objectives.

In the next 10 years, our greatest aspiration is to lead in gas production in a profitable and sustainable manner, contributing to the energy transition in the Ecopetrol Group's strategy and consolidating our position in the focus areas of Colombia. Likewise, we must advance in increasing our technical and commercial capabilities, making the most of our gas infrastructure, extend and increase the portfolio, develop projects and initiatives in water positivity, promote solutions based on nature, advance in the energy transition strategy and generate maximum social value for the country, the territories where we operate and in general, for all our interest groups.

The good results and stability of Hocol and the Ecopetrol Group translate into benefits and opportunities for the development and growth of the regions and the country.

The Innovation strategy proposed for 2022 – 2024 involves the inclusion of different management models such as open innovation, to complement the internal capabilities of the organization and thus manage to address strategic challenges through a model of collaboration and co-creation with external actors.

Currently there is a limitation to achieving this objective given that a significant number of hydrocarbon producing fields operated by Hocol are mature and approaching their economic limit (at which point it is no longer profitable to produce them and keep them open). This has limited the investments required to implement the tasks and technical elements necessary to monitor the operational variables described above.





¿What objectives are associated with the open innovation challenge?

The document presented below refers to the challenge: **¿How to reduce sulfur levels in the crude oil produced by HOCOL in mature fields?** for:

- Reduce the sulfur content of heavy crude oil operated by Hocol to permissible values for the transportation of hydrocarbons in Colombia, avoiding penalties/discounts that affect the economic limit of the fields and their development projects.
- Find or design the appropriate chemical or physical treatment technology or a compound of both with the highest cost-benefit ratio, which allows reducing sulfur levels in Hocol crude oil to a permissible limit for transportation (sulfur concentration in crude oil  $\leq 1.5\%$ ) and that can be implemented from the production fields.

## 1. PROBLEM

Currently, mature fields such as La Hocha, Río Saldaña and Ibamaca produce crude oil with sulfur percentages in crude oil between 2.5% and 3.6%, which are higher than those established in the ASTM 4294 standard. This situation could affect the price of crude oil. These fields are considered mature and have crude production projections of more than 15 years.

There are different solutions for reducing sulfur in crude oil, such as: hydrodesulfurization towers, which are not viable for HOCOL projects due to their complexity, objective and implementation cost. However, the challenge seeks to evaluate existing technologies or new technologies that allow obtaining the desired sulfur levels with the best cost-benefit ratio.

Hocol is carrying out a characterization of the crude oil to understand the causes of the sulfur levels, as well as oxidation tests of sulfur compounds in the La Hocha, Ibamaca, and Río Saldaña fields, where the presence of thiobenzenes and thiophenes is identified, with little presence of mercaptans.

Some solutions tested by Hocol correspond to projects with external research groups and chemical tests carried out by the internal team, based on scientific articles published in indexed journals.

Field tests have also been carried out with adsorption agents that have not been successful, despite having good results in laboratory tests.

The mature fields where the solution is expected to be implemented are characterized by being in remote locations with limited infrastructure to meet the production capacity of each field. Therefore, addressing improvement opportunities



and process needs have infrastructure, budgetary, technological, transportation limitations, among others.

These reasons restrict the integration of high-cost or complex solutions due to the conditions of implementation, energy consumption, pressure, temperature or technological adoption.

Taking into account the above, it is necessary to look for physical, chemical or physical-chemical solutions that allow reducing the percentage of sulfur in the crude oil resulting from the production of the 3 fields mentioned above to levels in a range between 1.1% and 1.5%.

## 2. ¿WHO IS THIS CHALLENGE AIMED AT?

HOCOL is looking for companies or teams interested in solving the challenge: ¿How to reduce sulfur levels in the crude oil produced by HOCOL in mature fields? with creative, innovative and implementable alternatives.

The possible solvers for this challenge can be:

- Companies (national or international) that have identified the problem with the state of the art and that they have a solution at a level minimum of TRL6.
- Alliances of university groups (national or international) with Startups that are exploring sulfur removal solutions and are at a minimum level of TRL5.

This call does not have a geographical restriction and will receive proposals at a national/international level, as long as they respond to the specified requirements based on the variables indicated for the solution. The solvers must have the ability to produce the pilot and implement its result in the fields.

## 3. TYPE OF RELATIONSHIP BETWEEN HOCOL AND SOLVERS

Once a solution is selected, the solution will be tested by the solver, which will have the possibility of direct award depending on the results and the company's decision.

For the development of the pilots, the solver is expected to carry out at least the following activities:

- Visit to 3 mature fields located in Tolima and/or Huila.
- Review the operating conditions and facilities of the prioritized fields.
- Establish a minimum volume of crude oil to carry out the pilot.

For all cases, it is expected that the results of the effectiveness of the solution to reduce the percentage of sulfur in the crude oil from the selected fields will be validated multilaterally, that is, both the solver and Hocol will carry out the chemical



tests in certified laboratories and trustworthy of each of the parties, the verification method accepted by Hocol is ASTM 4294.

#### 4. WHAT IS EXPECTED FROM THE SOLUTION?

Physical - chemical solutions that reduce the sulfur level of crude oil in mature fields (Río Saldaña, Ibamaca and La Hocha) to below 1.5%, prior to the commercialization stage.

Some solution conditions expected to address the challenge are:

- Solutions with hydrocarbon-soluble additives.
- The solution should not be expensive to operate or implement, in accordance with the productive and economic capacities of the mature fields.
- Solutions that have been tested in controlled environments (minimum TRL 5 and above).
- Solutions that can be integrated into the production process, modular, small that can be installed within a line or pipeline.
- Solutions already tested in refined products that can be adapted to crude oil.
- Solutions that can be customized to the characteristics of the sulfur found in the crude oil from the fields prioritized by Hocol.
- Method for determining sulfur in crude oil according to ASTM 4294.
- Solutions proposing methods of energy efficiency, specifically those that operate under ambient pressure and temperature.

The expected solutions may be injection skids, filtration units or chemical dosing points, without being limited to these forms.

#### 5. SELECTION CRITERIA

The solutions will be evaluated based on the following criteria:

Criteria	Description	Percent weight
Solution Maturity Level	The solution has been tested, proving to be successful in addressing the problem established by the challenge (Minimum TRL5)	20
Technical knowledge	The solver has experience, technical skills and capabilities relevant to meet the challenge. It has an interdisciplinary team with	20





	technical capabilities that can support the proposed solution	
Innovation	The proposed solution addresses the challenge in a novel or unconventional manner, and it aligns with the conditions described in the challenge.	20
Description	The proposed solution is clear, includes technical information and budget to understand how the pilot test will be developed. Furthermore, it demonstrates in its proposal the intention to work collaboratively with the challenging team.	20
Time	The proposed solution has a pilot test development time that aligns with the complexity of the solution.	20
<b>Total score</b>		<b>100</b>

## 6. EXPECTED IMPACT OF THE SOLUTION

As measurable indicators for the solution, the following are established:

- Reducing sulfur levels in crude oil within a range of 1.1% to 1.5%.

## 7. PARTICIPATION BENEFITS

The selected solver will receive the following benefits:

- Specialized guidance from Hocol during the solution's testing in an environment controlled by Hocol.
- Public recognition for the selected solver within the hydrocarbon sector's business circles.
- Possibility of direct award based on the test results and the company's decision.